U.S. Army Corps of Engineers

Final Geophysical Prove-out (GPO) Plan

Mojave Gunnery Range “C” (MGRC)
Kern County, California

Contract No. W912PL-06-0008, 0001

U.S. Army Corps of Engineers
Los Angeles District
915 Wilshire Blvd.
Los Angeles, California 90017

Prepared by:

MARRS Services, Inc.
13360 Firestone Boulevard, Suite 2A
Santa Fe Springs, CA 90670

May 29, 2007

[*This page intentionally left blank.*]

TABLE OF CONTENTS

Section | Page

ACRONYMS

ASR	Archive Search Report
CESPL	United States Army Corps of Engineers, Los Angeles District
DID	Data Item Description
DGM	Digital Geophysical Mapping
GIS	Geographic Information System
GPO	Geophysical Prove-Out
GPS	Global Positioning System
MARRS	MARRS Services, Inc.
MEC	Munitions and Explosives of Concern
MGRC	Mojave Gunnery Range “C”
MRA	Munitions Response Area
NGS	National Geodetic Survey
PLS	Professional Land Surveyor
QC	Quality Control
RI	Remedial Investigation
RTK	Real-time Kinematic
TDEM	Time-domain Electromagnetic
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance

[*This page intentionally left blank.*]

1.0 GEOPHYSICAL PROVE-OUT PLAN

This plan provides a description of the Geophysical Prove-Out (GPO) approach for the overall Mojave Gunnery Range "C" (MGRC) Remedial Investigation (RI) process. The purpose of the GPO is to evaluate Digital Geophysical Mapping (DGM) geophysical instruments, determine the standard response of selected instruments, evaluate instrument configurations, deployment techniques, and provide operator certification for instrument use. The GPO will be performed in accordance with Data Item Description (DID)s MR-005-05 and MR-005-05A. All data obtained during the GPO will be submitted to United States Army Corps of Engineers, Los Angeles District (CESPL) in accordance with the MGRC project guidelines. Mobilization to perform DGM at the MGRC will not begin until the CESPL reviews and concurs with the findings of the GPO.

The objective of the GPO is to evaluate technologies and equipment that can accurately detect and map Munitions and Explosives of Concern (MEC) items typically found within the MGRC. The GPO will evaluate the site-specific performance of the geophysical equipment, the positioning equipment and operator, as well as the data processing and management systems to be deployed to the field. The findings of the GPO will be used to develop the Data Quality Objectives (DQOs) for the data acquisition, processing, and interpretation parameters for the production surveys. The design of our test plot allows for prove-out of systems in both total-survey coverage and single-path transect modes for both detector-aided visual investigations and DGM investigations. The equipment selected for prove-out and potential use for DGM includes the Geonics EM61-MK2 Time-Domain Electromagnetic (TDEM) high-sensitivity metal detector and the Geometrics G858 cesium vapor magnetometer. These instruments may be used with a variety of positioning systems; however, the primary positioning system will be the Trimble 4700/5700/R7 Real-Time Kinematic (RTK) Global Positioning System (GPS) for both acquisition and reacquisition positioning activities. Additional systems or equipment proposed for field use will require testing and evaluation at the GPO test plot or site specific test strip prior to field deployment.

The equipment selected for prove-out and potential use for detector-aided visual investigations and the intrusive investigation includes the Schonstedt GA-52 fluxgate magnetic gradiometer and the Garrett GTI-2500 electromagnetic handheld detector.

1.1 TEST PLOT DESIGN

1.1.1 Test Plot Size and Location

MARRS will construct a single test plot within the primary geologic setting. The test plot will be constructed within a desert terrace (plain) setting. This setting was selected because it represents the dominant geologic setting where geophysical data will be obtained. The proposed test plot will be approximately 100 ft by 100 ft (32 m by 32 m). The actual size and location of the test plot will be determined based on client, stakeholder, and project requirements; however, the proposed GPO test plot location is located on the Hyundai property adjacent to the south central portion of the MGRC, as shown in Figure 1.

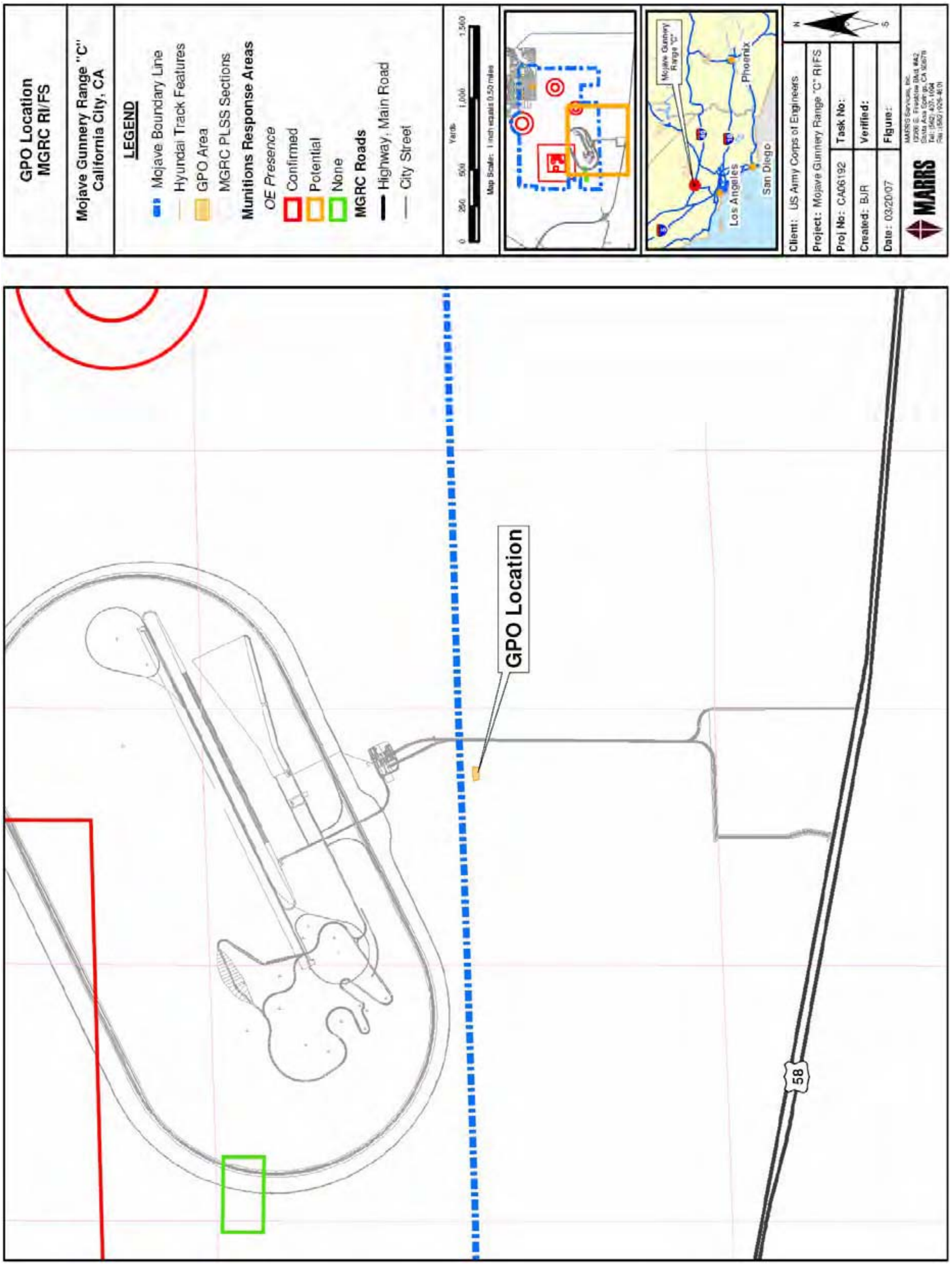


Figure 1, Proposed MGRC GPO Test Plot Location.

The test plot will be established such that it may be used to prove-out geophysical systems in both total-survey coverage and transect modes. Distribution of munitions seed items within the test plot will be pseudo-random to allow prove-out of systems in both the total survey coverage and linear transecting methodologies. The test plot will include a standardization line and adequate survey control for setup and evaluation of positioning systems used during the prove-out process. The conceptual design of the test plot is shown in Figures 2 and 3. The test plot comprises semi-permanent metal markers at the grid corners, the end-points of the proposed transects and at both ends of the reference profile. The instrument calibration point at the mid-point of the reference profile will be established using a non-metallic hub to eliminate interference during instrument calibration.

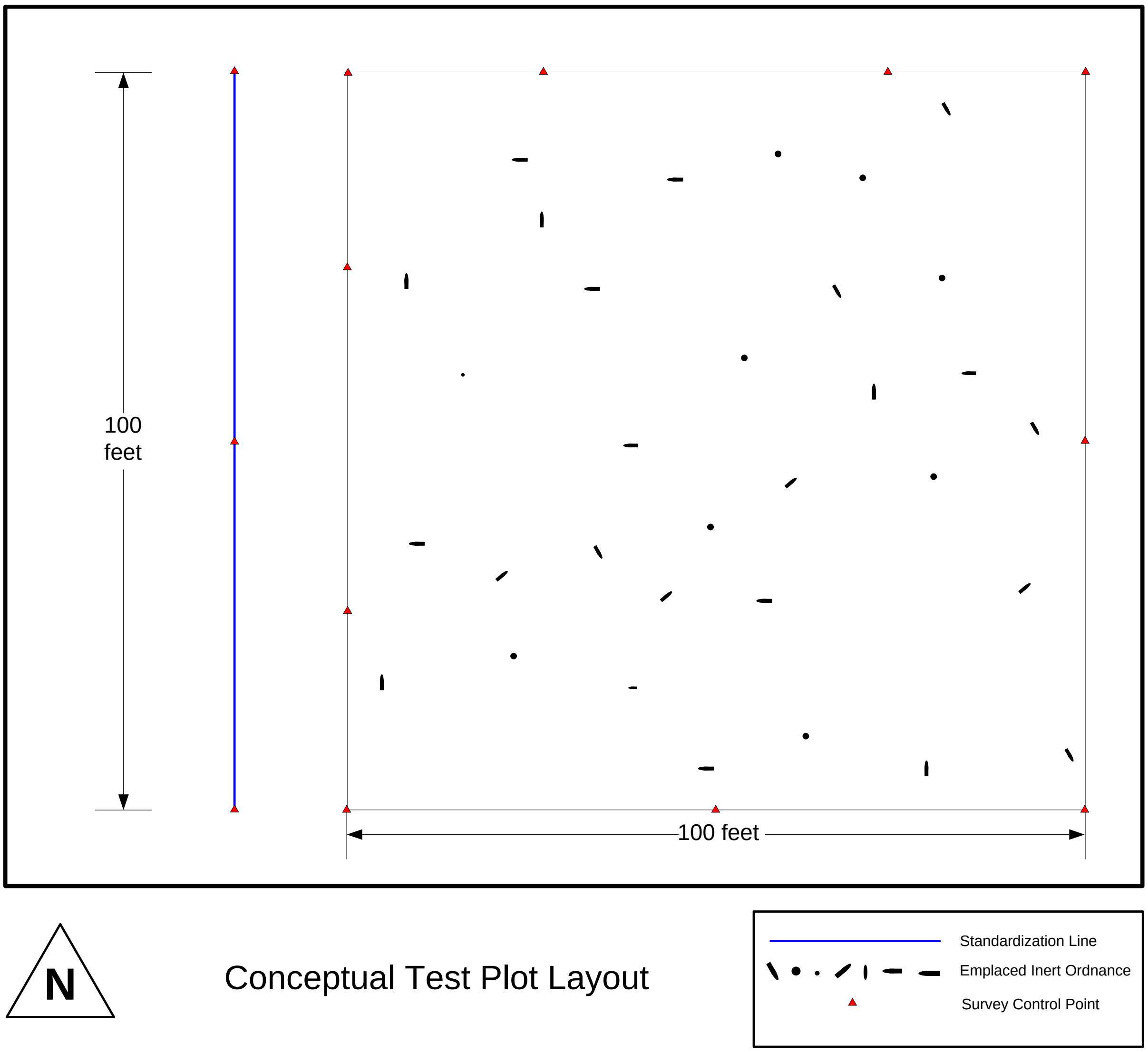


Figure 2, Test Plot Conceptual Design.

To use the test plot for total-coverage prove-out of systems, data will be acquired using appropriately spaced (system-based) transects to achieve total-coverage across the entire test plot. To use the test plot to prove-out systems in the linear transect mode, a line is extended between perimeter control points to create a network of single-path transect lines as shown in Figure 3.

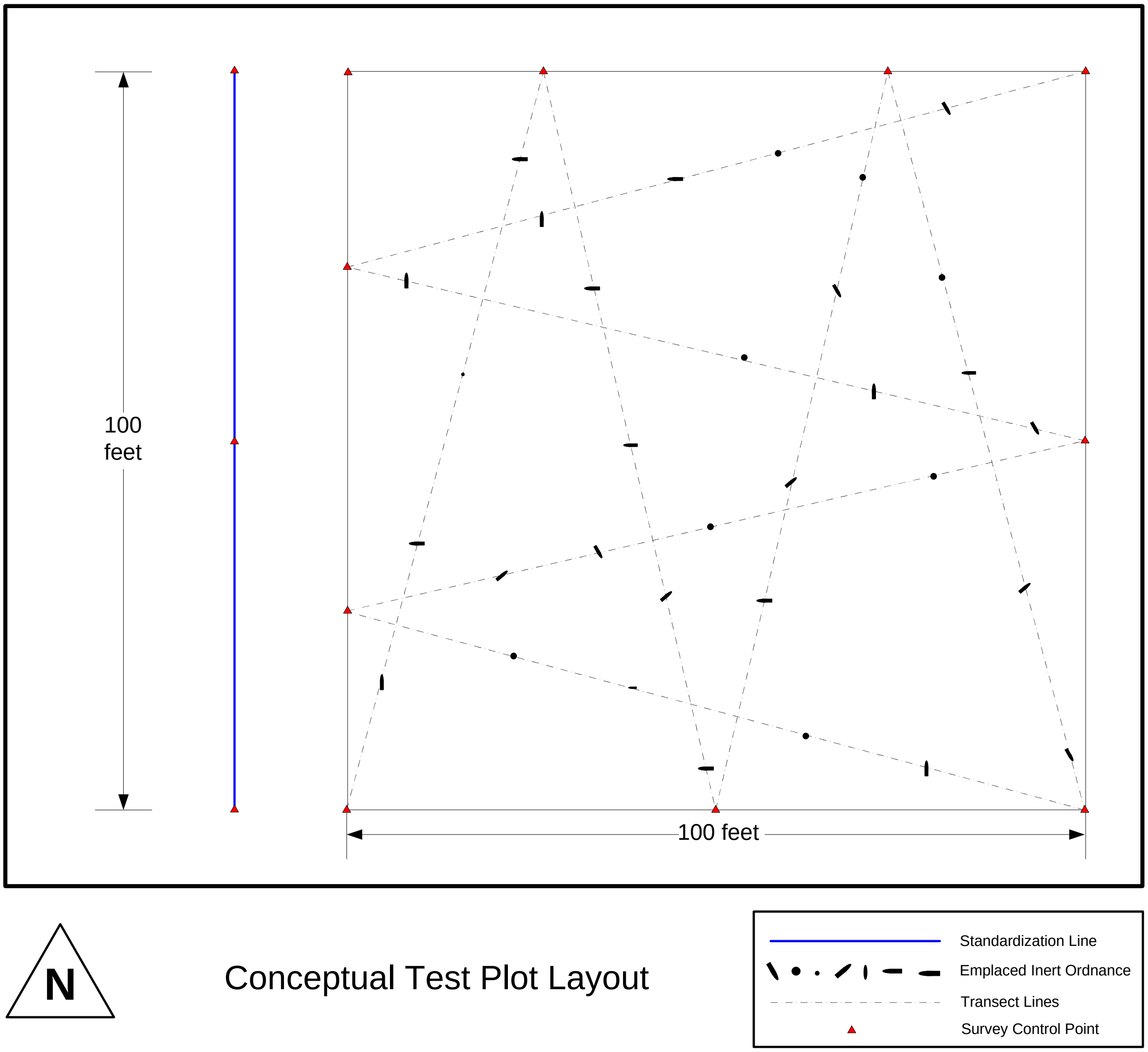


Figure 3, Systems Prove-out Design for Transect Mode Operations

1.1.2 Seed Items

Inert munitions items and munitions simulants, clearly marked as inert, are designated as munitions seed items. Use of inert munitions items are preferred over munitions simulants and will be used when available. The munitions seed items will be painted blue and tagged with a non-biodegradable label identifying the items as inert and providing the contract number, a point of contact address, phone number, and target identifier.

Munitions seed items will be emplaced within the Test Plot at various locations and buried at various depths in accordance with this plan. The coordinates, depths, and orientation of each munitions seed item will be surveyed, recorded and used as part of the GPO process. Information on the munitions seed item locations and depths will be migrated to and maintained within the GPO Geographic Information System GIS and not released to the geophysical test participants until after prove-out of their system(s).

The MGRC Archive Search Report (ASR) indicated munitions use ranging in size from 20mm projectiles to 1,000-lb Bombs. The detection depths for the 100-lb through 1,000-lb practice and general purpose high explosive (HE) bombs will be evaluated based on the results of other GPO munitions, calculated response based on mass, or existing empirical data. Due to the large size, availability and difficulty of emplacement for these items we do not propose to use or simulate the larger munitions in the test plot. It is anticipated that the 100-lb practice bombs constructed of sheet metal will not penetrate to depths greater than 2 feet below the ground surface. It is anticipated that the smallest munitions item will be a 20mm projectile. The geophysical equipment will be configured to detect the smallest munitions of concern at the maximum depths listed in Table 1.

Table 1, Munitions and Calculated Detection Depths

Munitions	Munitions diameter in / mm	Calculated Detection Depth feet / meters
20mm TP, (Mk1/M55/M99)	0/79 / 20	0.7 / 0.22
20mm HEI, (Mk1/M55/M99)	0/79 / 20	0.7 / 0.22
2.25-inch Practice, SCAR (Mk4)	2.25 / 57	2.1 / 0.63
2.75-inch Practice, FFAR	2.75 / 70	2.5 / 0.77
2.75-inch HE, FFAR	2.75 / 70	2.5 / 0.77
5-inch Practice, HVAR (MK6)	5.0 / 127	4.6 / 1.40
3-lb Practice, Cast Iron (AN-MK23) (Mk4)	2.2 / 56	2.0 / 0.61
3-lb Practice, Zinc (AN-MK5) (Mk4)	2.2 / 56	2.0 / 0.61
25-lb Practice, (BDU-33/MK76) (Mk4)	4.0 / 102	3.7 / 1.12
56-lb Practice, (Mk89) (Mk4)	4.0 / 102	3.7 / 1.12
100-lb Practice, (M38A2) (M1A1)	8.18 / 208	7.5 / 2.29
100-lb Practice, (MK15 MOD3) (M1A1)	8.0 / 203	7.3 / 2.24
500-lb Practice, (MK5/15/21)	15.0 / 381	13.7 / 4.19
20-lb Fragmentation, (AN-MK41)	3.64 / 92.5	3.3 / 1.02
100-lb General Purpose HE, (AN-M30A1)	8.18 / 208	7.5 / 2.29
250-lb General Purpose HE, (AN-M57A1)	10.9 / 277	10.0 / 3.05
500-lb General Purpose HE, (AN-M64A1)	14.18 / 360	13.0 / 3.96
1000-lb General Purpose HE, (AN-M65A1)	18.8 / 477.5	17.2 / 5.25
Bomb Unit, Practice, (BLU61-A/B)	3.9 / 99	3.6 / 1.09
Bomb Unit, Practice, (MK118 MOD0/MOD1)	2.1 / 53	1.9 / 0.58
Landmine, Practice, (VS-50)	3.5 / 90	3.2 / 0.99

NOTE: This table assumes intact munitions items. The actual detection depths are often different than the calculated maximum detection depth values from DID MR 005-05.

1.2 SITE PREPARATION

A GPO location that presents minimal subsurface clutter is desirable and considered in identifying the specific GPO footprint where munitions seed items will be installed. Prior to the performance of a background survey and test plot installation, a surface clearance will be performed to remove all visible metal from the footprint of the proposed test plot. It is anticipated that other types of metal detecting instruments (e.g., Schonstedt™ GA 52 magnetometers and Garrett GTI-2500 metal detectors) will be used to scan the standardization area and test plot location to assist in the removal of existing metal. The assessment will include evaluation of the site for a suitable area to perform system calibration and testing.

The area selected for the GPO is located within the Hyundai test facility, and is currently void of vegetation.

1.3 LOCATION SURVEYING

All coordinates will be recorded in Universal Transverse Mercator (UTM), Zone 11N, grid coordinate system and referenced to the National Geodetic Survey (NGS) NAD83, and presented in meters. Location surveying and establishment of survey control for GPO setup will be performed by a California-licensed Professional Land Surveyor (PLS).

Extents of the test plot, location (ends and center) of munitions seed items, and other required control points will be surveyed to an accuracy of at least 0.1 ft (3 cm) horizontally and 0.16 ft (5 cm) vertically. As stated previously, additional survey control points will be added to the perimeter of the plot to allow prove-out of systems in the single-path transect mode. Additionally, three control points will be surveyed in close proximity to the test plot for system calibration, static response evaluation, standardization and dynamic evaluation. Other survey control, such as positional base station control points will be established as required by the PLS. The test plot grid corners, the transect end points, and calibration strip end points will be marked in the field with #8 rebar (or equivalent). Positional data including the extents of the test plot and location (ends and center) of seeded targets will be migrated to and maintained within the GPO GIS.

1.4 PRE-SEEDING INVESTIGATION

After a suitable test plot location has been identified the final step in the pre-seeding process is to perform a background investigation over the selected test plot with each type of equipment proposed for use during this investigation. These pre-seeding investigations will include an investigation of the calibration strip to be used in standardization of all equipment and an investigation of the test plot prior to seed emplacement. The background readings within the calibration strip and test plot will be used to document existing anomalies. During the background survey, any anomaly that is detected by either DGM system will be considered an “existing anomaly” and marked as a “non-emplaced” item. The location and response of these “existing anomalies” will be documented and used in the final seed placement and analysis for the effects of these items in the prove-out results.

1.5 QUALITY CONTROL (QC)

QC standards for the GPO will reflect the same QC procedures as proposed for the field operations. These QC procedures will follow the accepted procedures laid out in Attachment B of DID MR-005-05.

The quality control elements and procedures for the GPO will include:

- Equipment Setup / Warm-up
- Personnel Test
- Sensor Positions
- Mechanical Vibration Test (cable shake)
- Static Test
- Reference Item Test
- 6-line Test
- Azimuthal Test (Magnetometer only)

- Octant Test (Magnetometer only)
- Height Optimization (For variable height instruments)
- Dynamic Noise Evaluation

1.6 ANOMALY AVOIDANCE

Standard UXO avoidance techniques will be used to ensure the location of each excavation and corner marker/stake is clear of metallic anomalies before placing seed items, corner markers and survey control hubs/stakes. The results from the background investigation will be used as a primary avoidance tool by mapping potential targets in the field prior to inserting any seed items.

1.7 SEEDING

Seeding will be performed using mechanical/manual excavations to facilitate the proper placement of target items. The munitions seed items will be installed in the test plot using the pseudo-random placement previously described. The location, orientation, and depth below ground surface to the top of each seed item will be surveyed in accordance with Section 1.3 and recorded for use in future evaluations. Table 2 provides details of the proposed munitions seed items, depth and orientations to be used within the test plot. This table presents the anticipated munitions seed items to be emplaced within the test plot; however, the actual items used in each test plot will be dependant upon the availability of the items described in this list. Figure 4 presents the proposed layout of the test plot including the GPO grid control points, the standardization line and the proposed distribution of the seed items. Table 3 provides the proposed seed item locations in feet; as grid offset dimensions in the x and y directions from the southwest corner of the GPO grid. The final GPO target layout including the actual munitions seed items used, their location, and orientation will be submitted to the CESPL geophysicist for final approval and presented in the "as-built" configuration maps and tables.

In addition to the seed items placed by MARRS, the CESPL will place additional blind seeds within the test plot. Detection of these items will be evaluated by the CESPL geophysicist. The results of the CESPL evaluation could potentially affect the geophysical data and analysis DQOs.

1.8 DATA COLLECTION VARIABLES

Data acquisition will follow the same procedures as proposed for the production survey. After functional checks and standardization have been performed at the established standardization area, the geophysical methods, systems and equipment will be deployed in the proposed operating modes within the test plot. Sample rates and lane spacings will be representative of the proposed field investigation protocols and production survey operations. The Project Geophysicist will document all prove-out details including instrument type, operators, equipment setup/quality results, date, and time and data filename in the geophysical field log.

Data acquisition parameters for each type of equipment will be evaluated during the GPO. These parameters will include geophysical equipment, positioning systems, lane spacing, acquisition rates, and survey speeds. We will also consider the survey method as a data collection variable which may include both transect data acquisition and total coverage acquisition. Data collection and instrument standardization will be performed in accordance with DID MR-005-05.

Table 2, Munitions Seeding Guidelines

Item Number	Item Description	Site Name	Grid Located	Depth in inches[1]	Azimuth Angle[2]	Inclination Angle[3]
GPO-01	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	8.5	0	90
GPO-02	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	4.5	0	90
GPO-03	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	8.5	0	0
GPO-04	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	4.5	90	0
GPO-05	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	6.5	0	90
GPO-06	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	6.5	90	0
GPO-07	2.25in SCAR Practice Rocket	GPO	Test Plot	25	0	90
GPO-08	2.25in SCAR Practice Rocket	GPO	Test Plot	12	0	90
GPO-09	2.25in SCAR Practice Rocket	GPO	Test Plot	25	0	0
GPO-10	2.25in SCAR Practice Rocket	GPO	Test Plot	12	90	0
GPO-11	2.75-inch Practice, FFAR Warhead	GPO	Test Plot	30.5	0	90
GPO-12	2.75-inch Practice, FFAR Warhead	GPO	Test Plot	15	0	90
GPO-13	2.75-inch Practice, FFAR Warhead	GPO	Test Plot	30.5	0	0
GPO-14	2.75-inch Practice, FFAR Warhead	GPO	Test Plot	15	90	0
GPO-15	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	55	0	90
GPO-16	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	27.5	0	90
GPO-17	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	55	0	0
GPO-18	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	27.5	90	0
GPO-19	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	24	0	90
GPO-20	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	12	0	90
GPO-21	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	24	0	0
GPO-22	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	12	90	0
GPO-23	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	24	0	90
GPO-24	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	12	0	90
GPO-25	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	24	0	0
GPO-26	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	12	90	0
GPO-27	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	44	0	90
GPO-28	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	22	0	90
GPO-29	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	44	0	0
GPO-30	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	22	90	0

1. Depth in inches to the nearest half inch based on the calculation (11 x diameter in mm)/1000
2. Azimuth measured clockwise from magnetic north in direction of the ordnance item nose (N = 0, E = 90, S = 180, W = 270)
3. Inclination measured positive downward in direction of the ordnance item nose (horizontal = 0 degrees, nose down = 90)

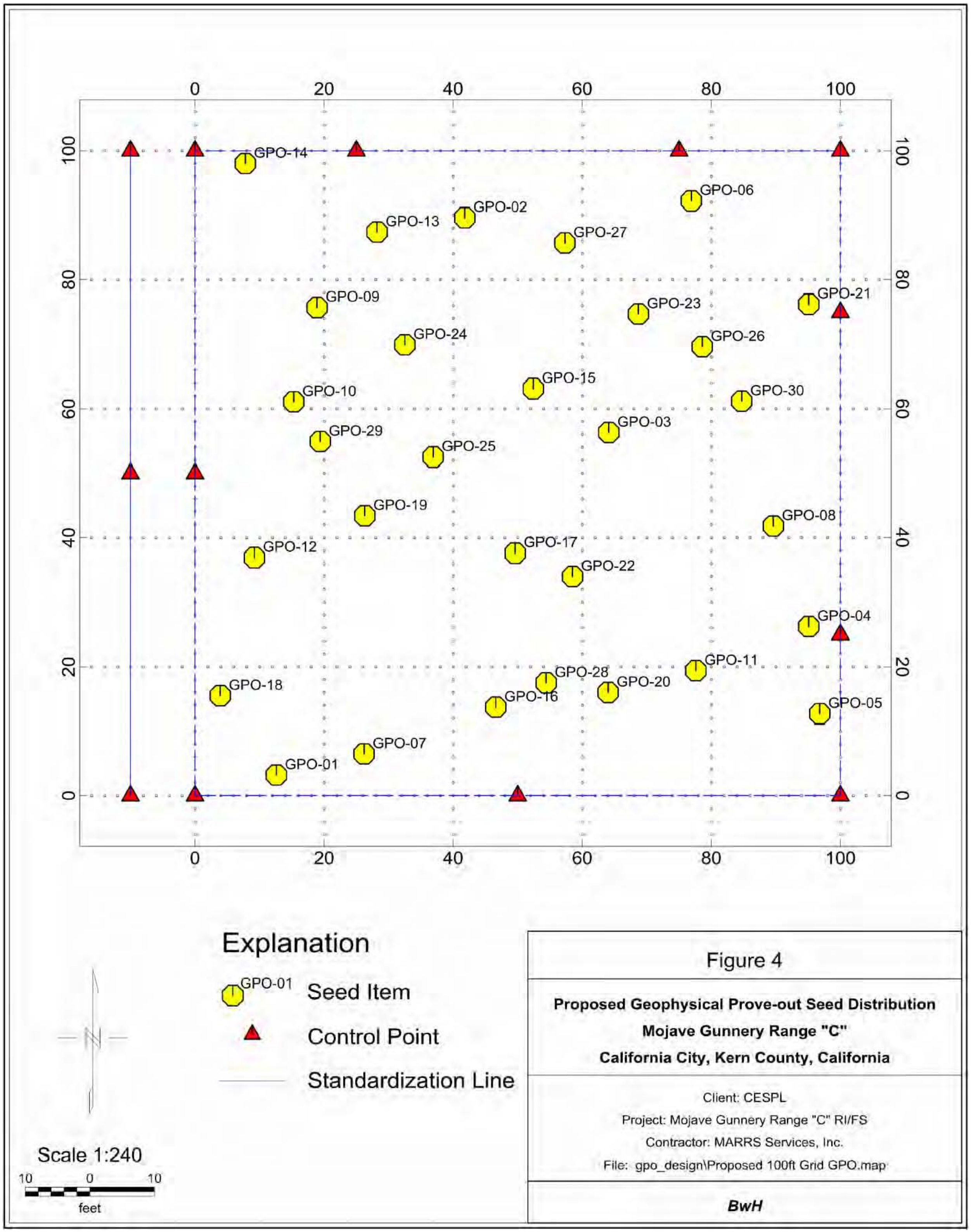


Figure 4, Proposed MGRC GPO Test Plot Seed Locations.

Table 3, Munitions Seeding Distribution and Grid Offsets

Item Number	Item Description	Site Name	Grid Located	Proposed Grid Location X offset	Y offset
GPO-01	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	12.6	3.2
GPO-02	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	41.8	89.6
GPO-03	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	64.1	56.3
GPO-04	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	95.1	26.2
GPO-05	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	96.8	12.7
GPO-06	20mm TP, (Mk1/M55/M99)	GPO	Test Plot	76.9	92.2
GPO-07	2.25in SCAR Practice Rocket	GPO	Test Plot	26.2	6.5
GPO-08	2.25in SCAR Practice Rocket	GPO	Test Plot	89.6	41.8
GPO-09	2.25in SCAR Practice Rocket	GPO	Test Plot	18.9	75.7
GPO-10	2.25in SCAR Practice Rocket	GPO	Test Plot	15.3	61.1
GPO-11	2.75-inch HE, FFAR Warhead	GPO	Test Plot	77.6	19.4
GPO-12	2.75-inch HE, FFAR Warhead	GPO	Test Plot	9.2	36.9
GPO-13	2.75-inch HE, FFAR Warhead	GPO	Test Plot	28.2	87.4
GPO-14	2.75-inch HE, FFAR Warhead	GPO	Test Plot	7.8	98.0
GPO-15	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	52.4	63.1
GPO-16	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	46.6	13.7
GPO-17	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	49.6	37.6
GPO-18	5-inch Practice, HVAR (MK6) Warhead	GPO	Test Plot	3.9	15.5
GPO-19	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	26.3	43.4
GPO-20	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	64.0	16.0
GPO-21	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	95.1	76.2
GPO-22	3-lb Practice, Cast Iron (AN-MK23) (Mk4)	GPO	Test Plot	58.5	34.0
GPO-23	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	68.7	74.7
GPO-24	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	32.5	69.9
GPO-25	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	36.9	52.5
GPO-26	3-lb Practice, Zinc (AN-MK5) (Mk4)	GPO	Test Plot	78.6	69.6
GPO-27	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	57.3	85.7
GPO-28	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	54.4	17.5
GPO-29	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	19.4	54.9
GPO-30	25-lb Practice, (BDU-33/MK76) (Mk4)	GPO	Test Plot	84.7	61.2

Grid Offset from SW corner in feet
Coordinates NAD83 UTM Zone 11N in meters to be determined
Magnetic Declination = 12.59 Degrees E

The data collection variables to be evaluated will include:

- Geophysical Equipment
- Instrument Height / Orientation / Direction of Travel
- Sampling Rate / Survey Speed
- Measurement Interval / Lane Spacing
- Positioning Method / Equipment
- Data Integration
- Instrument Channel Selection

1.8.1 Geonics EM61 MK2 Acquisition Parameters

Data collection will be performed using real-time integration of the EM61 and RTK GPS data streams using the Allegro data logger. The minimum sampling rate to be used for the EM61 will be 8 readings per second for the man-portable sensor. A single transect along each predefined segment will be obtained to evaluate transect based survey performance. For grid-based performance evaluation, parallel transects will be spaced at 2.75 ft (0.84 m) intervals with the spacing between transects not to exceed 3.28 ft (1 m). Data acquisition will be performed using a two-man production crew.

During the GPO data acquisition an average along track data spacing of 0.5 ft (16 cm) will be employed. Based on these data the along track coverage requirements can be evaluated to determine the maximum data spacing that can be used to effectively locate each munitions item. This will provide a range of sample spacings required to allow identification of various ordnance items within GPO.

1.8.2 Geometrics G858 Acquisition Parameters

Data collection will be performed using real-time integration of the G858 magnetometer and RTK GPS data streams using the Geometrics data logger. The minimum sampling rate to be used for the G858 will be 8 readings per second for the man-portable sensor. A single transect along each predefined segment will be obtained to evaluate transect-based survey performance. For grid based performance evaluation parallel transects will be spaced at 2.5 ft (0.76 m) intervals with the spacing between transects not to exceed 3.0 ft (0.91 m). Data acquisition will be performed using a two-man production crew.

During the GPO data acquisition an average along track data spacing of 0.5 ft (16 cm) will be employed. Based on these data the along track coverage requirements can be evaluated to determine the maximum data spacing that can be used to effectively locate each munitions item. This will provide a range of sample spacings required to allow identification of various ordnance items within GPO.

1.9 DATA ANALYSIS AND INTERPRETATION

MARRS will utilize equipment-specific data acquisition and field processing software to perform data acquisition and conversion to x, y, z, and response values for additional data processing. Data analysis and interpretation for both magnetic and electromagnetic data will be performed using Geosoft Oasis Montaj™, UX Process™, and UX Detect™.

Initial data processing will include the record keeping review, download and positioning of field data, and QC evaluation. QC evaluation will include mechanical, static and dynamic noise evaluation, standard response results, and data coverage. Standard data processing will be performed only after it has been shown that the data conform to the existing QC standards. Acceptable data will then be subjected to diurnal corrections where appropriate, sensor drift corrections, any leveling or sensor bias corrections, and latency corrections. After all corrections have been applied, data interpretation is performed.

Data interpretation includes the analysis, target selection, and presentation of results. The geophysicist will determine the optimum processing parameters to include the gridding method, search criteria, display parameters, and additional filtering techniques. A review of the gridding results compared to the system noise parameters will be used to determine the optimum target selection criteria for evaluation of these data. After DGM data processing and interpretation, selected targets with predicted coordinates are migrated to the GPO GIS for dig sheet and map generation. The geophysical mapping results and data evaluation will be presented in accordance with DID MR-005-05.

The data analysis and interpretation results will be evaluated based on:

- Data Coverage based on Measurement Interval and Lane Spacing
- Positional Accuracy based on Known Seed Coordinates
- Instrument Response
- Percent of Seeded Items Detected
- Number of unknown Targets

1.9.1 Anomaly Characterization

Anomaly characterization is an iterative approach used to evaluate DGM results in an attempt to classify a given anomaly. Anomaly characterization is best suited to total survey coverage investigations because total survey coverage reduces the investigation variables of sensor position, sensor orientation, and sampling location with respect to the target location. As such, total survey coverage results can be used to determine target characteristics. Transect-based survey coverage is best suited to determining distribution and density of metallic debris, and should be used carefully to evaluate individual target characteristics. Although anomaly characterization will not be used to score the performance of the geophysical systems, it will be used as a reference for anomaly characterization of the production-survey results.

The ability to characterize a detected target as either a MEC or non-MEC item is valuable to the remediation process by potentially reducing the number of non-MEC items (false alarms) that are investigated. However, target characterization is best performed as an iterative approach based on anomaly characterization and intrusive investigation results. At a minimum, anomaly characterization should include parameters describing the amplitude, size (width and area), and shape of the anomaly for each target selected. Depending upon the instrument used, additional estimates of target depth and/or mass may also be calculated. Secondary distinctions that can be made include the classification of targets as metallic or non-metallic based on signal decay rates. Additional information may be evaluated to assist in classification of targets as surface clutter items or targets at depth.

Anomaly characterization may be based on a combination of the following:

- Instrument Response (anomaly magnitude)
- Anomaly characteristics (size and shape)
- Target Characteristics (mass and depth)

- Time Constant (EM)
- Decay Rate (EM)

1.10 REACQUISITON

Reacquisition of DGM targets will evaluate the ability to navigate back to the predicted target location. Target reacquisition will be performed using RTK GPS and the same type of geophysical system used for data acquisition. Predicted target coordinates are transferred from the GPO GIS to the RTK GPS survey controller for navigation to the selected target. Upon arrival at the selected target location, the same type of geophysical system used for data acquisition will be used to verify and refine the target location; and to determine and record the reacquisition system response. The refined position will be recorded using RTK GPS and migrated to the GPO GIS for feedback and system performance analysis. The offset distance between the reacquired target and the actual target location will be calculated and recorded to evaluate the effectiveness of the reacquisition process. The success rate of the reacquisition process will be evaluated based on the DID MR-005-05 requirements stating that “Horizontally, 95% of all excavated items must lie within a 1.2 ft (35 cm) radius of their mapped surface location as marked in the field after reacquisition.”

1.11 DATA EVALUATION

Each system (operator, equipment and processing) will be evaluated against the baseline target set within the GPO GIS. As previously stated, anomalies identified during the pre-seeding investigation will be logged into the database as background items and will not be included for calculation of the detection rate and the number of unknown targets. Evaluation will be performed for each system’s mode of use. The Project Geophysicist will evaluate the effectiveness of MEC detection systems based on their performance in five general categories:

Detection – the ability to detect targets, represented by the percent of seeded items detected.

Characterization (target identification and classification) – the ability to discriminate between MEC and non-MEC targets based on the characteristics of each target identified, represented by the number of unknown targets.

Production Rate and Cost– based on each system’s field and processing performance.

Equipment Durability – based on observations during data acquisition.

Safety – based on observations during data acquisition.

[*This page intentionally left blank.*]

2.0 GPO LETTER REPORT

The results of the GPO will be presented in the GPO Letter Report. This letter report will contain the following information supporting our equipment recommendations:

- Introduction and GPO objectives
- As-built drawing of the Test Plots
- Catalogue of the seed items including photographs and placement information
- Summary of the equipment, procedures, data processing and data management
- GPO results including: Data QC Packages, color result maps, and GPO results
- Electronic data from GPO investigations
- Proposed geophysical equipment, technology, and methods for the production survey
- DQOs will be developed for data acquisition, processing and interpretation
- Data to support project recommendations

This information will be provided to the CESPL geophysicist prior to performing production geophysical investigations at the MGRC.

[*This page intentionally left blank.*]

3.0 HEALTH AND SAFETY PLAN

MARRS will perform the GPO work in accordance with the Accident Prevention Plan (APP) presented in Appendix D of the MGRC RI Work Plan. If the Accident Prevention Plan (APP) is not approved prior to the GPO activity, an Abbreviated Accident Prevention Plan (AAPP) will be completed and approved by the lead OE Safety Specialist before mobilization.

[This page intentionally left blank.]

MARRS Services, Inc.
101 State Place, Suite O
Escondido, CA 92029
Tel. 760.233.7507
Fax. 760.233.7510

October 12, 2007

Mr. Matthew Shun
USACE Los Angeles District, CESPL-PM-M
915 Wilshire Boulevard, Suite 15011
Los Angeles, California 90017-5009

Subject: Final Geophysical Prove-Out Report
Former Mojave Gunnery Range C
California City, California

Dear Mr. Shun,

The purpose of this report is to summarize the Geophysical Prove-Out (GPO) performed at the former Mojave Gunnery Range C (MGRC) site from June 4-12, 2007 by MARRS Services Inc (MARRS). The GPO was conducted in accordance with the Final Geophysical Prove-Out Plan, Former Mojave Gunnery Range C, dated May 2007, to evaluate the effectiveness of the specified geophysical instruments to detect specific munitions items at various depths and orientations found throughout the Former MGRC.

INTRODUCTION

The site selected for the GPO was located within the south central portion of the Hyundai North America Proving Grounds, along the southern boundary of the MGRC shown in Attachment A, Plate 1. This site was selected based on access, availability, and the previously mitigated biological concerns allowing full access to the GPO site. The GPO grid was established by burying munition seed items characteristic of those expected to be found throughout the MGRC ranges based on historical archives. The seed items emplaced within in the GPO were buried by MARRS, the U.S. Army Corp of Engineers (USACE) and California Department of Toxic Substance Control (DTSC) representatives. This report contains a summary of the results obtained from the data collected using four different types of geophysical instruments. The four instruments used were a Geonics EM61-MK2 time domain metal detector, a Geometrics G-858 magnetometer, a Garrett GTI-2500 handheld metal detector and a Schonstedt GA-52Cx handheld magnetic gradiometer.

OBJECTIVES

The primary objective of the GPO was to demonstrate the capabilities of various items of geophysical equipment within the site-specific environment, and allow the selection of the most appropriate and effective geophysical instrument(s) for use during the remedial investigation (RI). In addition, the data collected during this GPO were used to verify conformance of the geophysical instruments with Data Item Description (DID) MR-005-05 (Geophysical Investigation Plan) in regards to the anomaly depth detection criteria, and develop Data Quality Objectives (DQOs) and anomaly selection criteria for use in the field investigation.

PROVE-OUT GRID SET-UP

Prior to the emplacement of the munition seeds within the 32-m by 32-m (100-ft by 100-ft) prove-out grid, surveys were conducted with the EM61-MK2 and G-858 sensors linked with the real-time kinematic (RTK) global positioning system (GPS) to map background site conditions. Four background anomalies were identified from the background investigation data. These four background anomaly targets were investigated using the handheld detector instruments and were identified as small pieces of metallic surface debris. These items were removed from the grid to eliminate the occurrence of background anomalies associated with surface debris within the GPO grid. MARRS then buried 30 items designed to represent munitions and explosives of concern (MEC) within the GPO plot at the locations shown in Attachment A, Plate 2. An additional undisclosed number of items were buried by USACE and DTSC personnel and are considered blind seed items. The GPO grid will be left in place or removed at the discretion of USACE.

SEED ITEMS

The GPO grid was seeded with a variety of items designed to represent munitions and explosives of concern (MEC) expected throughout the MGRC as reported in the Archive Search Reports (ASR) and field evaluations. The seed items consisted of both inert munitions and simulated munitions (fabricated from pipe with the approximate mass and dimensions). Thirty seed items were buried by MARRS and all project personnel knew their locations. Attachment B Table 1 shows the type, size, and construction material for each of the known seed items. Attachment C contains photographs of each seed item prior to emplacement within the GPO grid.

Seed items for the 2.25-in rockets consisted of only the rocket motors. Seed items for the 2.75-in rockets consisted of only an inert warhead. For the 5-in HEAT rockets, an inert 5-inch ZUNI rocket warhead was used based on availability and difficulties dealing with the complete dimensions of the warhead and motor combined. Miniature practice bombs listed in the ASR's and the Final GPO Plan include both the cast iron AN-MK23 and the zinc AN-MK5 3-lb practice bombs. Other practice bombs in the ASR included the BDU-33/MK76. Finally, based on recovery of 20mm high explosive incendiary (HEI) projectiles during previous construction activities at the MGRC, twenty 20mm target practice (TP) projectiles were also included in the test plot.

In addition to the MARRS seed items, an undisclosed number of quality assurance seed items were emplaced by USACE and DTSC representatives. Neither the location nor number of these blind seed items were disclosed to MARRS field and office personnel.

SEED LOCATIONS

The seed items were buried at various depths and orientations to determine how the different geophysical instruments would respond to these factors within the site-specific environment. Every effort was made to bury these items at the depths listed in the GPO Work Plan, but an unconsolidated dry sandy soil resulted in some of the deeper planned seed items being placed at shallower depths due to sloughing. Additionally with approval of the USACE and DTSC on-site representatives four of the planned larger seed items were replaced with four 20mm TP projectiles to achieve a better depth and orientation distribution for analysis of the 20mm TP targets. The location, depth, and orientation of the seeds were recorded by a Professional Land Surveyor (PLS) licensed in the State of California (E.G. Chapman, Inc of San Diego, CA). Attachment A, Plate 2 shows their locations based on the central survey position and Attachment B, Table 2 documents the type, depth, and orientation of the known seed items. The survey coordinates for the nose, tail, center, and ground surface of each seed item are presented in Attachment B, Table 3.

GEOPHYSICAL SURVEY EQUIPMENT

GEONICS EM61-MK2 TIME DOMAIN METAL DETECTOR

The EM61-MK2 (also referred to as EM61) consists of two 0.5 by 1 meter coils, separated vertically by a distance of 30-cm, which are set on a pair of wheels and pulled by the operator. The EM61 device generates an electromagnetic pulse that triggers eddy currents in the subsurface. The eddy current decay produces a secondary magnetic field that is monitored by a receiving coil or coils. These secondary magnetic fields are received as data and stored in a data logger with the GPS positioning data. The EM61 data logger collects data at automatic time intervals determined by the user (approximately twelve times per second). The logger can also be set to record data received from the top coil and three different time gates from the bottom coil; or from four different time gates from the bottom coil. For this prove-out, data were logged at a rate of 10 hertz (Hz) and was recorded from the four time gates of the lower coil. Additionally two different coil heights were evaluated based on using 20-inch and 16-inch wheels.

GEOMETRICS G-858 MAGNETOMETER

The G-858 magnetometer uses cesium vapor magnetometer sensors that include a miniature atomic absorption unit from which a signal proportional to the intensity of the ambient magnetic field is derived. The sensitivity of the instrument is 0.05 nanoTesla (nT) and it can collect readings as fast as ten times per second. Two sensors were used during all of the magnetometer surveys, with the sensors mounted on a tow cart and separated horizontally by 76 cm (30 in). To evaluate the effect of sensor height on the detection capabilities of the magnetometer system three different sensor heights were used 6, 12- and 18-inches (15, 31- and 46-cm) above ground surface. For this prove-out, the earth's magnetic field data were logged at a rate of 10 hertz (Hz) and was recorded from the top and bottom sensors.

GARRETT GTI-2500 METAL DETECTOR

The Garrett GTI 2500® is a very low frequency (7.0 KHz) metal detector that utilizes a microprocessor controlled digital signal processor (DSP). The unit is a continuously adaptive motion / no-motion, handheld, all-metals detector that responds instantly to targets allowing the operator to search fast, slow or with no motion at all. The unit can be operated in one of eight selectable frequencies allowing multiple units to operate in close proximity to each other. The Garrett GTI 2500® is coupled with the 9-inch Scorcher Imaging Searchcoil enabling the instrument's advanced discrimination capabilities. The system's Auto Track feature allows the instrument to constantly adjust itself to changes in soil conductivity and surface clutter. The unit also features Graphic Target Imaging (GTI) utilizing the Graphic Target Analyzer™ (GTA), TreasureVision™, and TreasureTalk™ providing information regarding target size, depth, and material. An audio response signal is produced when a target is encountered, that increases in pitch and volume as the center of the search coil passes over the target. A Liquid Crystal Display (LCD) is available for visual indication of the relative target size and depth. The LCD also constantly displays battery strength.

SCHONSTEDT GA-52Cx GRADIOMETER

The Schonstedt GA52-Cx is a hand-held magnetic gradiometer that employs two flux-gate sensors aligned and mounted a fixed distance apart to detect changes in the earth's ambient magnetic field caused by ferrous metal. The Schonstedt magnetometer responds with an audio output when either sensor is exposed to a disturbance of the earth's ambient magnetic field associated with a ferrous metal object and/or the presence of a permanent field associated with a ferrous metal object. The Schonstedt magnetometer is highly portable compared to the EM61 or G-858 but does not record data. It also tends to be more sensitive to small variations in the magnetic field caused by items such as nails or ferrous rocks.

GLOBAL POSITIONING SYSTEM EQUIPMENT

A Trimble 5700/5800 RTK GPS was used to position the data collected during the EM61, and the G-858 surveys. It was also used to position the locations identified during the Garrett and Schonstedt surveys. For the EM61 surveys, the GPS antenna was placed on a tripod above the top coil and connected to the data logger. For the G-858 surveys, the antenna was attached to a backpack carried by the operator and data was output to the magnetometer's data logger. The Trimble 5700/5800 RTK is an integrated parallel channel GPS receiver with a built-in radio-modem communication system. A dedicated base station was used to broadcast real-time differential corrections to the rover units being used by the field crew. Positional data was output to the respective data loggers at 1-second intervals using a serial cable. Anomaly locations for the handheld surveys were recorded in the Trimble TSCE data logger for later upload to the computer.

GEOPHYSICAL SURVEY PROCEDURES

DATA ACQUISITION

For all geophysical investigations control points were established along the perimeter of the GPO test plot. These control points consisted of 8-inch long galvanized nails driven into the ground at the grid corners and transect end-points. These control points were used for evaluating the GPS positional accuracy and to serve as visual cues for transect based mapping. Approximately 20-feet (6 meters) east of the GPO test plot, a single calibration line was established in a geophysically "quiet" area with a PVC midpoint and nails at each end-point, as shown on Attachment A, Plate 2. This calibration line and the central point served as the calibration area for the static tests, reference item checks, latency tests for all equipment, as well as the heading test location for the magnetometer system. Finally, prior to collecting data throughout this site, reference flags were placed at one-meter intervals along both the northern and southern boundaries of the GPO test-plot. These reference flags were used by the data acquisition teams as guides for the end points of the geophysical survey transects.

EM61-MK 2 TIME DOMAIN METAL DETECTOR

The EM61 data were obtained by pulling the instrument north and south across the prove-out grid until complete coverage had been obtained. This task was performed using a two-man crew; one to pull the coil array cart and the other to carry and monitor the electronics equipment. For each instrument configuration, two EM61 surveys were performed to evaluate the data obtained by the instrument in both grid coverage and single transect modes.

The two wheeled instrument configurations for this investigation resulted in the standard bottom coil height of 40 cm (16 inches) and a top coil height of 70 cm (27.5 in) above ground surface; and the lower bottom coil height of 36 cm (14 inches) and a top coil height of 66 cm (26 in) above ground surface. The grid data were obtained using a nominal 2.5 ft (0.75 meter) line spacing, and single transects were obtained across the site along the 8 primary transect lines. All of these data were positioned using the RTK GPS. Data collection was recorded using a single line for each major component of the survey (e.g. one continuous line for the grid data, one continuous line for the north-south transects data, and one continuous line for the east-west transects data).

At the beginning and end of each EM61 survey, static and reference item tests were conducted to verify the operation of the instrument. These data were recorded at the base line calibration point while the instrument was held stationary. A 2-inch trailer ball was used as the reference item for this Prove-out. Plots of the EM61 static test data are included in Attachment D.

A 6-line test was collected along the calibration base line, showing that data collected over the same line, including an introduced spike in four of the six lines, is repeatable at different data acquisition speeds. It was also effective in delineating the latency associated with the EM61 system. A plot of the 6-line test data is included in Attachment D.

G-858 MAGNETOMETER

The total field magnetic data were obtained by pulling the instrument north and south across the prove-out grid until complete coverage had been obtained. This task was performed using one person to transport the sensor array and two persons to provide guidance for survey coverage across the site. For each instrument configuration total field magnetic data were obtained in the single transect mode, and grid coverage was obtained with only the lowest sensor height configuration. .

The man-portable tow-cart mounted configuration for the magnetometer investigation resulted in a two sensors magnetometer survey, with the sensors separated horizontally by 76 cm (30 in). To evaluate the effect of sensor height on the detection capabilities of the magnetometer system three different sensor heights were used 6-, 12- and 18-inches (15-, 31- and 46-cm) above ground surface. The grid data were obtained using a nominal 2.5 ft (0.75) meter sensor spacing and single transects were obtained across the site along the 8 primary transect lines. All of these data were positioned using the RTK GPS. Data collection was performed within a single line for each major component of the survey (e.g. one continuous line for the grid data, one continuous line for north-south transects data, and one continuous line for east-west transects data).

At the beginning and end of the magnetometer survey, static and reference item tests were conducted to verify the operation of the instrument. These data were recorded at the base line calibration point while the instrument was held stationary. A 2-inch trailer ball was used as the reference item for this Prove-out. Plots of the magnetometer static test data are included in Attachment D.

A 6-line test was collected along the calibration base line along the eastern edge of the grid. The 6-line test shows that the data collected over the same line, including an introduced spike in four of the six lines, is repeatable at different data acquisition speeds. It is also effective in delineating the latency associated with the G-858 magnetometer system. A plot of the 6-line test data is also included in Attachment D.

In addition to the 6-line test, an octant-test was also performed with the magnetometer. The octant test involves the collection of data in eight directions (N-S, S-N, NE-SW, SW-NE, etc.) over the geophysically "quiet" calibration point. These tests are designed to determine how the direction the operator is walking affects the amplitude of the magnetometer's response. If any differences are noted, they can be accounted for in post processing. Plots of the heading tests are included in Attachment D.

In order to obtain the best data possible, a magnetometer base station was used to record the diurnal variations in the earth’s magnetic field. These data were obtained using a single sensor G-858 total field magnetometer. The diurnal data were used to remove the effect of the observed variations from the magnetometer data. Even though the GPO magnetometer surveys were performed during a short period of time with little expected diurnal variation, we chose to maintain a magnetometer base station, as this would be the actual field procedure for long term magnetometer investigations.

GARRETT GTI-2500 METAL DETECTOR

A transect-based Garrett metal detector survey of the GPO grid was initiated in accordance with the Final GPO Work Plan. For transect-based investigations a rope was placed along the selected investigation path defined by the surveyed end points. The Garrett operator then proceeded to sweep the designated transect, flagging each target along the path. Subsequently, the position of each flag representing a target feature was recorded using the same RTK system used during digital data acquisition. The points were then downloaded to allow further processing and analysis within the Oasis Montaj GPO UX-Process module.

SCHONSTEDT GA-52Cx GRADIOMETER

A transect-based Schonstedt GA-52Cx gradiometer survey of the GPO grid was initiated in accordance with the Final GPO Work Plan. For transect-based investigations a rope was placed along the selected investigation path defined by the surveyed end points. The Schonstedt operator then proceeded to sweep the designated transect, flagging each target along the path. Subsequently, the position of each flag representing a target feature was recorded in using the same RTK system used during digital data acquisition. The points were then downloaded to allow further processing and analysis within the Oasis Montaj GPO UX-Process module.

DATA DOWNLOADING AND PROCESSING

EM61-MK2 TIME DOMAIN METAL DETECTOR

The EM61 data were imported into Geonics Dat61MK2 software for preprocessing. Dat61MK2 combines the EM61 data and the GPS positioning data collected during the project. The position of each data value is then interpolated based on the adjacent GPS readings. The resulting data set is automatically saved in

Geosoft XYZ format that can be imported into Geosoft's Oasis Montaj software. The prove-out data were processed using Geosoft's Oasis Montaj software and the following procedures:

- Conversion from WGS84 latitude and longitude to NAD83 UTM Zone 11N coordinates (GPS-located data).

- Latency correction using the values derived from the 6-line test conducted before field data acquisition. A 0.3 to 0.4 second latency correction was used for the EM61-MK2 data.

- Drift correction by subtraction of the median value from each data point in the four time-gate channels. The median was calculated using a 100-point rolling statistics filter.

- Gridding was performed using a 0.2-m grid node spacing and a blanking distance of 0.75-m.

Selection of anomalies representing potential Munitions and Explosives of Concern (MEC) was performed using Geosoft's UX Detect algorithm. Various anomaly selection criteria (thresholds) were evaluated for each of the grid files created for the EM data. The final threshold for each grid file was the one that selected as many seed items as possible in the respective grid file.

In order to further characterize each identified target the anomaly width, decay constants, and the sum of time gates 1 through 4 were determined. The decay constant between channels 1 and 4 for the anomalies selected in each data set generally fell within the same range and was not considered an effective method for further classification of these targets. Evaluating the target selection based on the summation of the time gates did not provide for improved target selection or improved signal to noise ratios. However, distinctions among the selected targets could be made based on variations in the anomaly width and amplitude, time-constant and decay rate.

G-858 MAGNETOMETER

The G-858 data were pre-processed using Geometrics MagMap 2000. Magnetic data pre-processing in Magmap includes the combination of the magnetic survey data and the GPS data collected simultaneously. If the GPS was used to position the data, the offsets from the GPS antenna to the center of each magnetometer sensor are entered into Magmap to correctly position the data collected by each sensor. Once the offsets are entered, the data can be exported into Geosoft XYZ format. Each XYZ file contains the position of the sensor based on the location of the GPS antenna and the offsets entered for that unit. All of the magnetic data sets were processed using Geosoft’s Oasis Montaj software. The G-858 data were processed using the following procedures:

- Conversion from WGS84 latitude and longitude to NAD 83 UTM Zone 11N coordinates (GPS-located data).

- Latency correction using the values derived from the 6-Line test conducted before the survey. A 0.01 to 0.4 seconds latency was used for the GPS-located data based on the sensor configuration.

- Drift correction was performed using the base station data obtained during the field survey.

- Gridding using 0.15-m grid node spacing and a blanking distance of 0.75-m was used when evaluating the magnetic field data and when calculating the analytic signal gird.

Selection of anomalies that are considered to be potential MEC was performed by the site geophysicist after running the created grid file through an analytic signal filter in Geosoft. The analytic signal filter returns only positive anomalies, making it easier to select anomalies at a consistent threshold and determine where the exact center of an anomaly should he located. Both the original grid, with the positive and negative responses shown, and the analytic signal grid were considered during selection of anomalies considered to be potential MEC.

GARRETT GTI-2500 METAL DETECTOR

The Garrett metal detector does not have the ability to record response data. When a real-time response indicative of buried metal was encountered the location of the response was marked as a target with a survey flag. The position of each target flagged by the operator was recorded using RTK GPS. These points were downloaded from the GPS data logger using Trimble Geomatics Office and exported as a CSV file for comparison with the locations of the known seed items within the Oasis Montaj GPO UX-Process module

SCHONSTEDT GA-52Cx GRADIOMETER

The Schonstedt gradiometer does not have the ability to record data. When a real-time response indicative of buried metal was encountered the location of the response was marked as a target with a survey flag. The position of each target flagged by the operator was recorded using RTK GPS. These points were downloaded from the GPS data logger using Trimble Geomatics Office and exported as a CSV file for comparison with the locations of the known seed items within the Oasis Montaj GPO UX-Process module.

RESULTS AND DISCUSSION

The results of the geophysical systems were compared based on three primary factors; (1) the detection rate, (2) the number and type of targets missed, and (3) the false alarm rate (FAR). In this case, the detection rate is based on how many targets were detected during the processing and interpretation as compared to the known targets. The number and type of targets missed is used to further evaluate system performance. The FAR is calculated by dividing the number of false alarms by the number of known targets detected plus the number of false alarms. Because an undisclosed number of quality assurance seed items were placed within the survey area, there is the potential for an elevated false alarm rate (FAR). In order to reduce the number of false positives an iterative approach was used to increase the target selection threshold to the highest acceptable level before the number of known seed item targets began to decline. By increasing the target selection threshold the total number of targets was reduced, thus lowering the number of FAR for each data set.

EM61-MK2 TIME DOMAIN METAL DETECTOR

The results of the four EM61 surveys performed at the prove-out grid are shown in Attachment A, Plates 3 through 6. The 40 cm (16 in) coil height transect survey detected 29 of the 30 seeded items (Plate 3); whereas the 36 cm (14 in) coil height transect survey detected 30 out of 30 seeded items (Plate 4). The 40 cm (16 in) coil height grid survey detected 27 of the 30 seed items (Plate 5); whereas the 36 cm (14 in) coil height grid survey detected 28 of the 30 seeded items (Plate 6). The interpretation results of the transect and grid data for the seed items are shown in Attachment B, Tables 4 through 7. As indicated in Table 4, only one of the items was missed in the 40 cm (16 in) coil height transect survey; the deepest inert zinc 3-lb practice bomb. As indicated in Table 5, no items were missed in the 36 cm (14 in) coil height transect survey. As indicated in Table 6 three items were missed in the 40 cm (16 in) coil height grid survey: the deepest 20mm TP projectile, the deepest cast iron 3-lb practice bomb and the deepest zinc 3-lb practice bomb. Finally, as indicated in Table 7, two items were missed in the 36 cm (14 in) coil height transect survey: the 20mm TP projectile buried at 4 inches and the deepest zinc 3-lb practice.

Among the items detected, the average positional deviation from the predicted seed locations were 0.23 m (0.74 ft) and 0.20 m (0.67 ft); for the 40 cm (16 in) coil height and 36 cm (14 in) coil height transect surveys, respectively. The average positional deviation from the predicted seed locations were 0.20 m (0.67 ft) and 0.27 m (0.67 ft); for the 40 cm (16 in) coil height and 36 cm (14 in) coil height grid surveys, respectively. The location coordinates for all anomalies selected as potential MEC in the EM61 surveys are presented in Attachment B, Tables 4 through 7 for each of the respective GPO tests.

To compare the selection threshold used for each method, the standard deviation of each channel was calculated in a geophysically quiet area in the data. The standard deviations calculated for channel 2 were

0.04 to 0.05 mV for the static background data survey and 0.21 to 1.13 mV for the dynamic background data. Using a threshold criteria of 1.5 times background noise, resulted in different initial selection thresholds for each configuration. Based on the differing response values for each coil height different target selection criteria were developed. After reviewing the targets resulting from a range of selection thresholds final threshold values of the 1.5 mV and 3.5 mV were applied to the 40 cm (16 in) coil height and 36 cm (14 in) coil height surveys, respectively. A review of the target lists indicated that some targets may have been missed by simply selecting targets based on channel 2. Based on a review of all the individual channels and the summation of all four data channels it was determined that for the standard 40 cm coil height that additional targets should be selected using a criteria of a summed response of greater than 3.5 mV to develop the most complete target data set. These selection criteria resulted in a FAR of 29% and a detection rate of 97% for the 40 cm (16 in) coil height transect data, and a FAR of 30% and a detection rate of 100% for the 36 cm (14 in) coil height transect data. These selection criteria resulted in a FAR of 29% and a detection rate of 90% for the 40 cm (16 in) coil height grid data, and a FAR of 67% and a detection rate of 93% for the 36 cm (14 in) coil height grid data. These FAR and detection rates do not include information regarding the unknown location of the QA seeds.

Further evaluation of the geophysical targets was performed by calculating target-widths, time-constants and decay curves. By reviewing plots of anomaly amplitude versus target-width and time-constant trends could be observed within the results. Anomalies were eliminated from each data set based on screening values developed to keep all known seed items and to reject anomalies suspected to have been caused by geophysical noise. The screening values for this investigation included anomaly amplitude, target width, and time-constant. The anomaly amplitude was based on grid values for the total coverage data and profile values for transect data. The target size was determined from the average distance between inflection points for the total coverage data and the anomaly half-width for transect data. For transect based data this resulted in an amplitude cutoff of 1.5 mV for channel 2 (366 μs time-gate) data, and a target size of less than 0.2. Results from the known seed items indicated a time-constant between channels 1 and 4 ranged from approximately 200- to 1,000-pico seconds; with values greater than 2,000 pico seconds representing non-UXO items.

G858 MAGNETOMETER

The results of the two magnetometer surveys performed at the prove-out grid are shown in Attachment A, Plates 7 through 10. The 15cm (6-inch) sensor height transect survey detected 23 of the 30 seeded items (Plate 7); whereas the 31cm (12-inch) sensor height transect survey detected 24 out of 30 seeded items (Plate 8)); finally the 46cm (18-inch) sensor height transect survey detected 23 out of 30 seeded items (Plate 9). The 15cm (6-inch) sensor height grid survey detected 23 of the 30 seed items (Plate 10). The interpretation results of the transect and grid data for the seed items are shown in Attachment B, Tables 8 and 11, respectively. As indicated in Table 8, six of the items were missed in the 15cm (6-inch) sensor height transect survey; two of the 20mm TP projectiles buried 6 inches bgs, one cast-iron 3-lb practice bomb buried 24 inches bgs, and three of zinc 3-lb practice bombs. As indicated in Table 9, six of the items were missed in the 31cm (12-inch) sensor height transect survey; two of the 20mm TP projectiles buried 6 and 8 inches bgs, one 2.25-inch SCAR rocket, one cast-iron 3-lb practice bomb buried 24 inches bgs, and two of the zinc 3-lb practice bombs. As indicated in Table 10 seven items were missed in the 41cm (18-inch) sensor height transect survey; two 20mm TP projectiles, one 2.25-inch SCAR rocket, the deepest cast iron 3-lb practice bomb and three of the zinc 3-lb practice bombs. Finally, as indicated in Table 11, seven items were missed in the 15cm (6-inch) sensor height grid survey: two 20mm TP projectiles buried at 6 inches bgs, one cast-iron 3-lb practice bomb buried 24 inches bgs and all of the zinc 3-lb practice bombs.

Among the items detected, the average positional deviation from the predicted seed locations were 0.74 m (2.44 ft), 0.37 m (1.22 ft), and 0.46 m (1.49 ft); for the 15cm, 31cm and 46cm sensor height transect surveys, respectively. The average positional deviation from the predicted seed locations were 0.25 m (0.82 ft) for the 15cm sensor height grid survey. The location coordinates for all anomalies selected as potential MEC in the G-858 magnetometer surveys are presented in Attachment B, Tables 8 through 11 for each of the respective GPO tests.

To compare the selection threshold used for each method, the standard deviation of each channel was calculated in a geophysically-quiet area in the data. The standard deviations calculated for the bottom sensor were 0.03 to 0.41 nT for the static background surveys and 1.8 to 3.1 nT for the dynamic background data. Using a selection criteria of 1.5 times background noise, allows a minimum selection threshold of 4.7 nT. After reviewing the targets resulting from the 4.7 nT threshold and the response amplitude of the known seed items, the target selection thresholds of 7, 10, and 15 nT were used for the 46cm, 31cm, and 15cm sensor height surveys, respectively. This resulted in a FAR of 29% and a detection rate of 80% for the 6-inch sensor height transect data, in a FAR of 49% and a detection rate of 80% for the 12-inch sensor height transect data, in a FAR of 53% and a detection rate of 77% for the 18-inch sensor height transect data, and a FAR of 47% and a detection rate of 77% for the 6-inch sensor height grid data. These FAR and detection rates do not include information regarding the unknown location of the QA seeds.

GARRETT GTI-2500 METAL DETECTOR

The results of the Garrett handheld transect survey performed at the prove-out grid are shown in Attachment A, Plate 11. The transect-based survey detected 21 of the 30 items. The interpretation results of the transect data for the seed items are shown in Attachment B, Table 12. As indicated 9 items were missed in the transect survey including; the deepest 2.25-inch SCAR rocket, the deepest 2.75-inch FFAR rocket, the two 5-inch HVAR rockets, the two 25-lb BDU-33 practice bombs, and the deepest zinc 3-lb practice bomb. It is readily apparent that the Garrett's handheld detector exhibits a primary limitation for detecting deeply buried items. This resulted in a FAR of 25% and a detection rate of 70% for the Garrett's transect data. These FAR and detection rates do not include information regarding the unknown location of the QA seeds.

Among the items detected, the average positional offset for the transect survey results was 0.10 m (0.34 ft). The location coordinates for all anomalies selected as potential MEC in the Garrett handheld survey are presented in Attachment B, Table 2 for the handheld detector GPO test.

SCHONSTEDT GA-52Cx GRADIOMETER

The results of the Schonstedt transect survey performed at the prove-out grid are shown in Attachment A, Plate 12. The transect-based survey detected 24 of the 30 items. The interpretation results of the transect data for the seed items are shown in Attachment B, Table 13. As indicated 6 items were missed in the transect survey including; two of the 20mm TP projectile, the deepest 2.75-inch FFAR rocket, two of the zinc 3-lb practice bombs and one of the steel 3-lb practice bombs. This shows that the Schonstedt is not effective for detecting non-ferrous items. This resulted in a FAR of 14% and a detection rate of 80%, for the Schonstedt transect data. These FAR and detection rates do not include information regarding the unknown location of the QA seeds.

Among the items detected, the average positional offset for the transect survey results was 0.17 m (0.57 ft). The location coordinates for all anomalies selected as potential MEC in the Schonstedt magnetometer survey are presented in Attachment B, Table 13 for the handheld detector GPO test.

REACQUISITION

On a preliminary basis, anomalies that could potentially be MEC were selected in the field from both the EM and magnetic data in order to determine the reacquisition capabilities of each instrument and to ensure that anomalies could be reacquired within a 0.37 m (1.2-ft radius) of the actual item location. To demonstrate the reacquisition capabilities the transect-based geophysical data were evaluated.

Results of the reacquisition are shown in Attachment B, Table 10. This table shows the final location of the field reacquired anomalies. This table shows the actual offset of the reacquired target location from the nearest surveyed location of the seed items. For the EM61, many of the reacquired target locations were virtually identical to the predicted location and could not be further refined. Results of the EM61 reacquisition indicated that all but one of the detected targets were within the 0.37 m tolerance of the actual item location. The G858 reacquisition investigation, however, indicated three reacquired targets outside the 0.37 m tolerance with one target outside a 0.5 meter radius. The main cause of error for the reacquired locations with the G858 results from the ambiguity of selecting the inflection point of a dipolar anomaly from the G858 real-time magnetic profiles in the field.

DETECTION RATE

The ability to detect MEC is considered the primary criteria for selecting a geophysical system. For this investigation a successful target selection was considered as any anomaly selected within 1-meter of the surveyed center location of any seed item. The detection rate was then calculated by dividing the number of selected targets by the number of known seed items. The detection rate was calculated for both systems that were used over the entire prove-out grid, the EM61 and G-858, and all four systems that were used in the transect mode.

The two EM61 surveys exhibited detection rates above 90% whereas the G-858 based surveys exhibited detection rates of 77% and 80%. The handheld detector systems (Garrett and Schonstedt) performed at detection rates of 70% and 80%, respectively. Attachment B Table 14 lists the target selection summary including the noise levels, FAR, and percent detection. The EM61 surveys had the best detection rate performance; for both the grid based and transect based investigations.

FALSE POSITIVES

While the ability to detect MEC is the primary criteria for selecting a geophysical system, the false alarm rate (FAR) should also be considered. For this GPO, a false positive was defined as any anomaly that was selected at a location without either a known seed item or a known background anomaly. The FAR can be calculated using the ratio of the number of false positives to the number of selected targets. For purposes of this investigation the definition exaggerates the FAR because some of the selected targets considered false positives may actually result from blind seed items or pieces of metal that were not selected from the background survey data. The FAR was calculated for all systems that were used during the prove-out grid.

Based on the objective of identifying a 20mm projectile very aggressive target selection thresholds were required during the interpretation of the GPO data resulting in abnormally high false alarm rates. The FAR results ranged from 14% to 67% for all of the methods employed during the GPO. The FAR for the EM61 investigations ranged from 29% to 47%, whereas the FAR for the G-858 investigations ranged from 29% to 67%. Additionally the handheld sensor investigations recorded FARs of 14% to 25%. Attachment B Table 14 lists the target selection summary including the noise levels, FAR, and percent detection. The EM61 investigations had the best combined detection and false alarm rate performance, for both the grid based and transect based investigations.

QUALITY CONTROL

Quality control for the former MGRC GPO data was maintained by performing instrument noise tests over a static test item with both instruments, collecting a 6-line test with both instruments, and performing an octant/heading test with the magnetometer. Prior to collecting any data personnel tests, vibration/cable shake tests were performed. Positional accuracy was determined by re-occupying the GPO control points with the RTK rover system, and comparing the geophysical results with targets from the GPO control points.

INSTRUMENT QUALITY CONTROL

Static noise, reference item, and 6-line tests were conducted before each instrument was used to survey the grid. The test was conducted along the background control line located 6-m east of the GPO grid. The center point on this line was designated as the calibration point and was established using a section of ¾-in PVC pipe for mounting the 2-in trailer ball for the reference item. With respect to system response the results were as expected with the reference item magnitude being slightly lower for the fast line and slightly higher for the slow line. All of these results were within the 20% of the observed response values. The 6-

line tests were also used for lag correction purposes in all of the surveys conducted. The latency correction for each instrument was applied using the DOD QMQC module in Oasis Montaj. Use of the correct latency value results in overlapping peaks when traveling in opposite directions. The results of the 6-line tests completed for each instrument are included in Attachment D.

Initial personnel tests and vibration test indicated no problems for the EM61 and G858 investigations. The static tests at the beginning and end of the day showed a standard deviation on the order of less than 1 mV for the EM61. The G858 magnetometer static tests showed peak-to-peak noise as typically less than 0.5 nT. The results of the static tests completed during the GPO are included in Attachment D. Some deviations in the reference item tests were observed in the magnetometer and EM61 tests. It has been determined that these deviations were caused by the operator moving the sensor during the reference item evaluation tests.

The octant tests performed with the magnetometer did not show any signal dropouts. The octant test shows a maximum range of offsets from -6.45 to 6.17 nT in the transect pairs with most pairs varying approximately 2 nT. The variation along the primary data acquisition directions ranged between -0.54 nT and 1.41 nT. The results of the octant tests are included in Attachment D. Height optimization was evaluated by comparing the difference in results from the various sensor configurations for both the EM and MAG systems. These data were compared along the test-strip to determine the relative signal to noise ratios for each of the systems being evaluated.

The GPS test was performed while the GPS antenna was attached to the RTK rover unit. The twelve nail-marked grid control points were re-occupied with the RTK rover and a single point was recorded for each location. This resulted in a range of positional errors from 0 m to 0.03 m with an average error of 0.01 m for all of the points investigated.

DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) were developed for the field portion of the project, based on the results of the GPO. The DQOs for the EM61 are presented in Attachment B, Table 16. The DQOs were developed using the following parameters of the data: Background noise 0.5 mV **-** Highest standard deviation of the data between the two surveys conducted, a sampling density of 20 cm (8 in) for 98% of the data, coverage gaps not exceeding the half width of the anomaly from the smallest MRA specific munitions**,** anomaly selection threshold of 1.5 mV on channel 2, additional anomaly selection threshold of 3.5 mV on the channel 1 through 4 summation, and reacquisition of 95% of the items recovered during the project within 0.37 m (1.2 feet) of their actual locations. These DQOs will be modified based on the MRA specific munitions and results from the site specific test strips utilized throughout this project.

These results are based on a review of the response characteristics from the most deeply buried small munitions at this site, the 20mm TP projectile buried 6-inches (15cm) bgs.. These results suggest that the use of all four time gates on the bottom coil of the EM61 will provide additional information regarding the time constant and decay rate for further characterization of the observed anomalies for improved target classification.

CONCLUSIONS AND RECOMMENDATIONS

Buried inert and simulated munitions items were detected using the EM61, G-858 magnetometer, Garrett GTI-2500 Metal Detector and the Schonstedt GA-52Cx Gradiometer at a prove-out grid located within the Former Mojave Gunnery Range C. The results indicate that the EM61 surveys were consistently able to detect more seed items than the G-858 magnetometer surveys were able to detect. The positional accuracy for both the initially predicted locations and the reacquired locations were more accurate for the EM61 than for the G-858 instruments. Additionally, the EM61 was able to detect 5 and 8 more seed items than either the Schonstedt GA-52Cx or Garrett GTI-2500, respectively. Although the EM61 with the 36 cm (14 in) sensor height was capable of detecting more of the seed items during the GPO the increased FAR and occurrence of numerous negative noise spikes within the data indicate that this configuration is not suitable for deployment at this time. Therefore, based on the 97% detection rate, the 29% FAR for the transect-based EM61 survey, and the ability of the EM61 to detect both ferrous and non-ferrous targets; we have selected the EM61 40 cm (16 in) sensor height as the geophysical investigation tool for this project.

Examination of the anomalies generated by the 20mm TP buried at 20 cm (8 in), and the Mk23 buried at 61 cm (24 in) indicates that these items were commonly missed or produced a response slightly above the background value. This resulted in a classification recommendation that anomalies with half-widths less than 0.2 m and with channel 2 response amplitudes less than 1.5 mV and summation response of less than 3.5 mV should be eliminated. This combination of response and anomaly width (designed to detect a 20mm TP round at 15 cm (6 in) may result in numerous targets from noise sources. In the event that excessive noise or false alarms are encountered both the acquisition and processing parameters may be modified based on survey conditions and in accordance with CESPL approval.

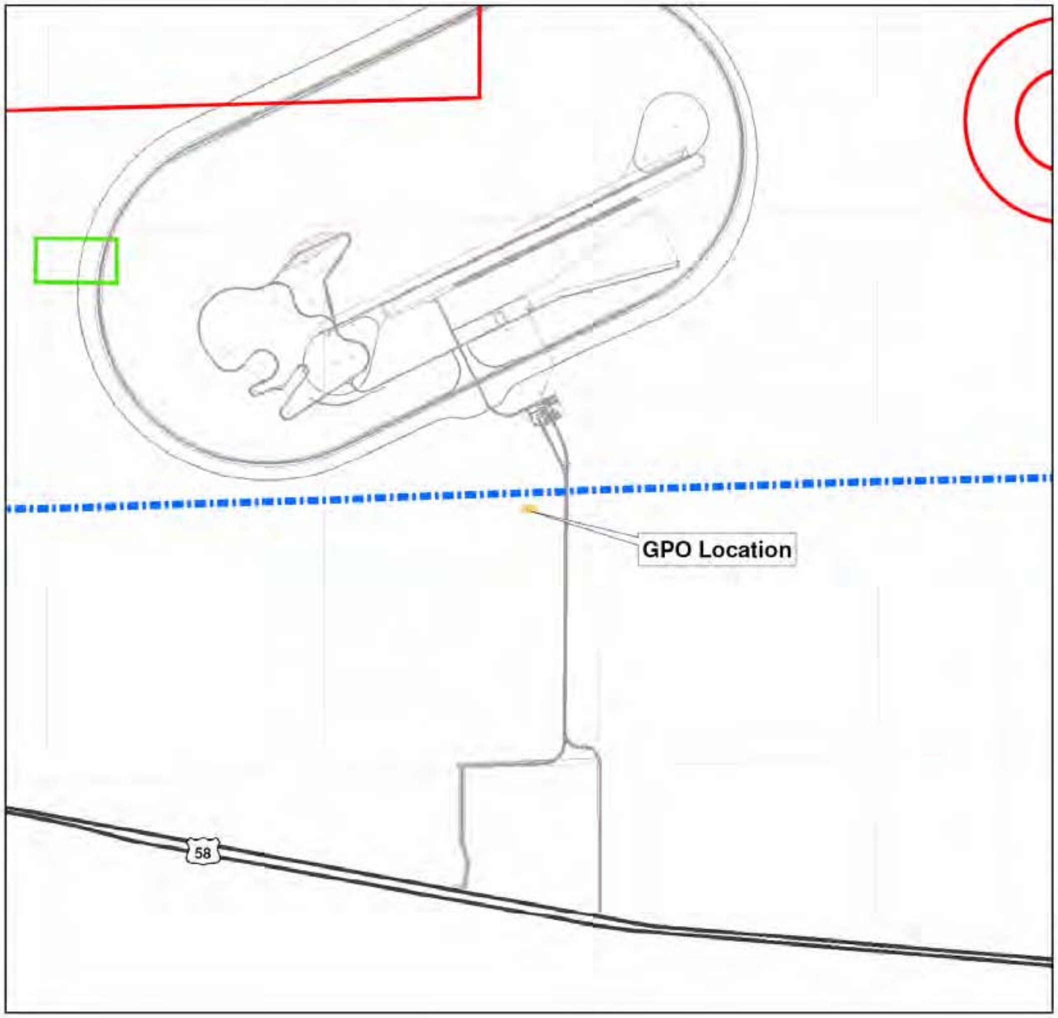
Based on the fact that this GPO was designed to simulate the anticipated geologic and ordnance items for the various MGRC Munitions Response Areas (MRA) it may not be possible to determine a single target selection criteria to effectively evaluate each MRA. Therefore these GPO data will be supplemented with results from on-site test strips that will allow regular monitoring of the geophysical response to the MRA-specific munitions items.

Finally, throughout the MGRC, there will be areas that are not accessible to the EM61. For the areas not accessible to the EM61 an alternative real-time investigation tool will be required to complete the munitions distribution characterization. The primary handheld investigation tool selected for the Mojave Gunnery Range "C" investigation is the Garrett GTI-2500 based on its superior ability to detect the 20mm TP projectiles. However, in areas where 20mm projectiles are not expected and larger or deeper ferrous items may be encountered the Schonstedt GA-52Cx would be the superior instrument. Therefore, the selection of the real-time investigation tool must be considered on a case-by-case basis considering the expected ordnance for the MRA under investigation.

Brian Hecker, GP-991
Senior Geophysicist, MEC Group

Attachment A

Figures



GPO Location
MGRC RI/FS

Mojave Gunnery Range "C"
California City, CA

LEGEND

- Mojave Boundary Line
- Hyundai Track Features
- GPO Area
- MGRC PLSS Sections

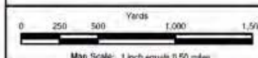
Munitions Response Areas

OE Presence

- Confirmed
- Potential
- None

MGRC Roads

- Highway, Main Road
- City Street

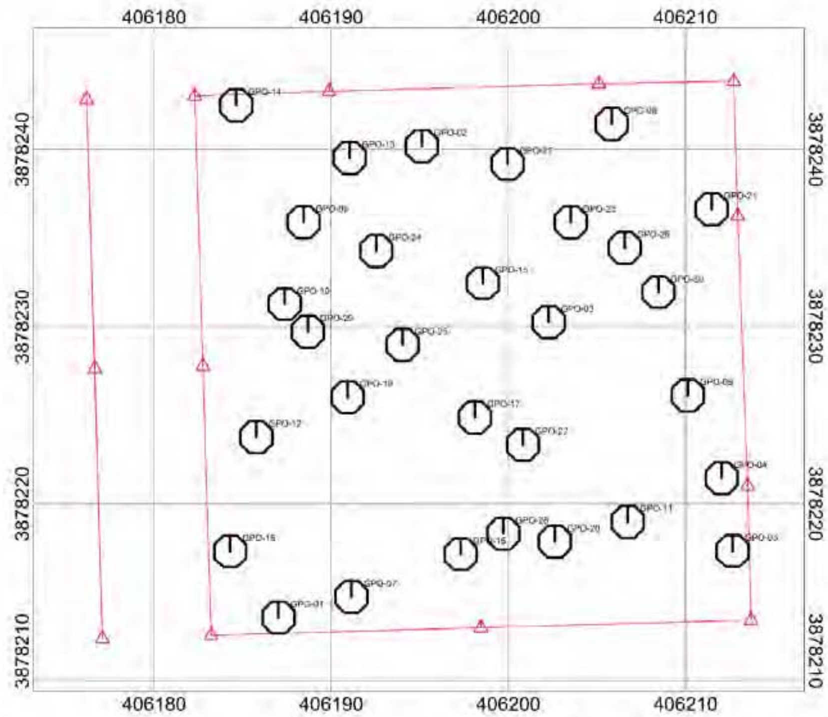


Client: US Army Corps of Engineers	
Project: Mojave Gunnery Range "C" RI/FS	
Proj No: CA06192	**Task No:**
Created: BJR	**Verified:**
Date: 03/20/07	**Plate:** 1

N
S

MARRS

MARRS Services, Inc.
13360 E. Firestone Blvd. #A2
Santa Ana Springs, CA 90670
Tel: (562) 407-1094
Fax: (562) 926-4601



Explanation

Seed Item

× Selected Target

Control Point

Scale 1:300

5 0 5

(meters)

NAD83 / UTM zone 11N

Plate 2

Seed Locations
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_Seed_Locations.map

BWH

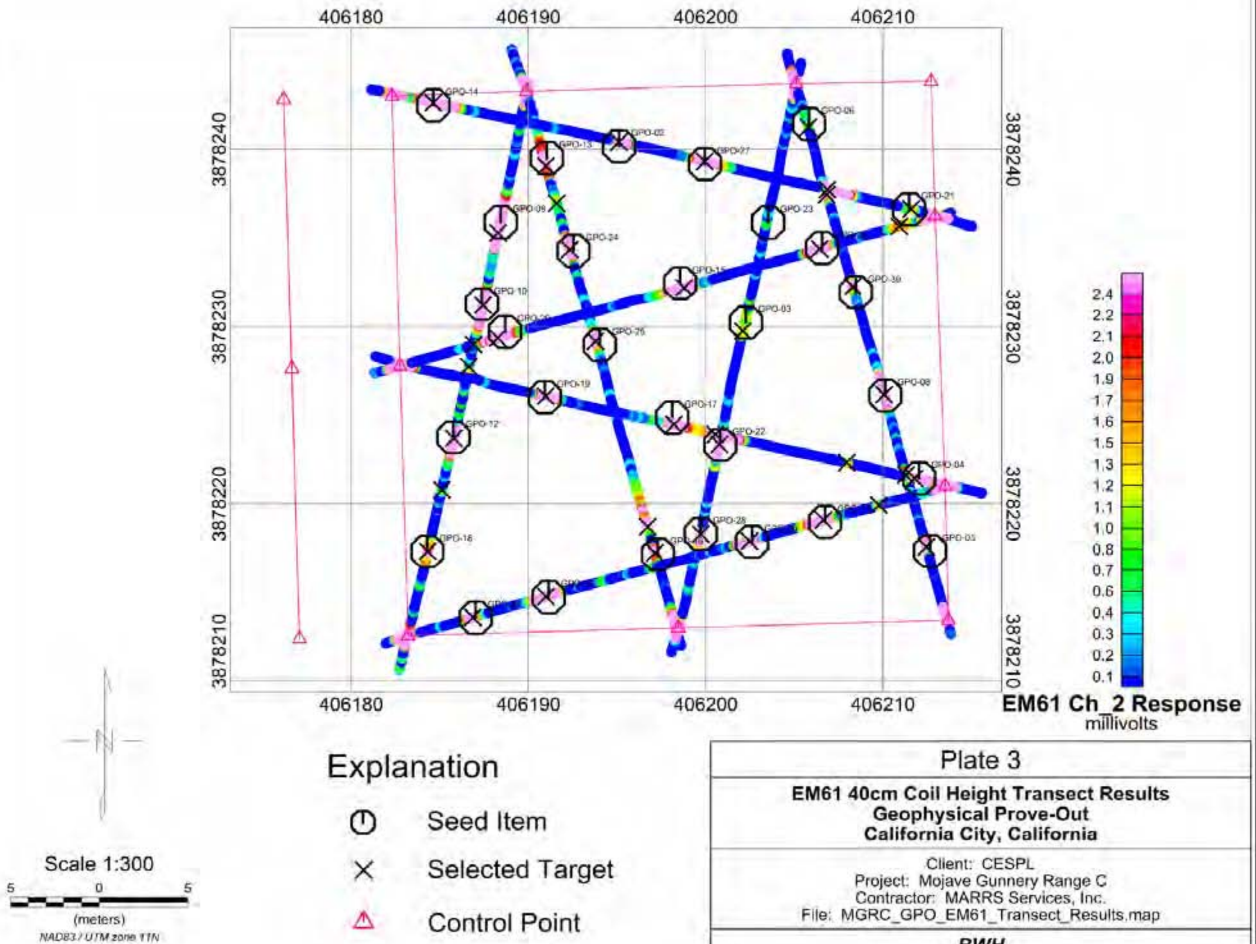


Plate 3

EM61 40cm Coil Height Transect Results
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_EM61_Transect_Results.map

BWH

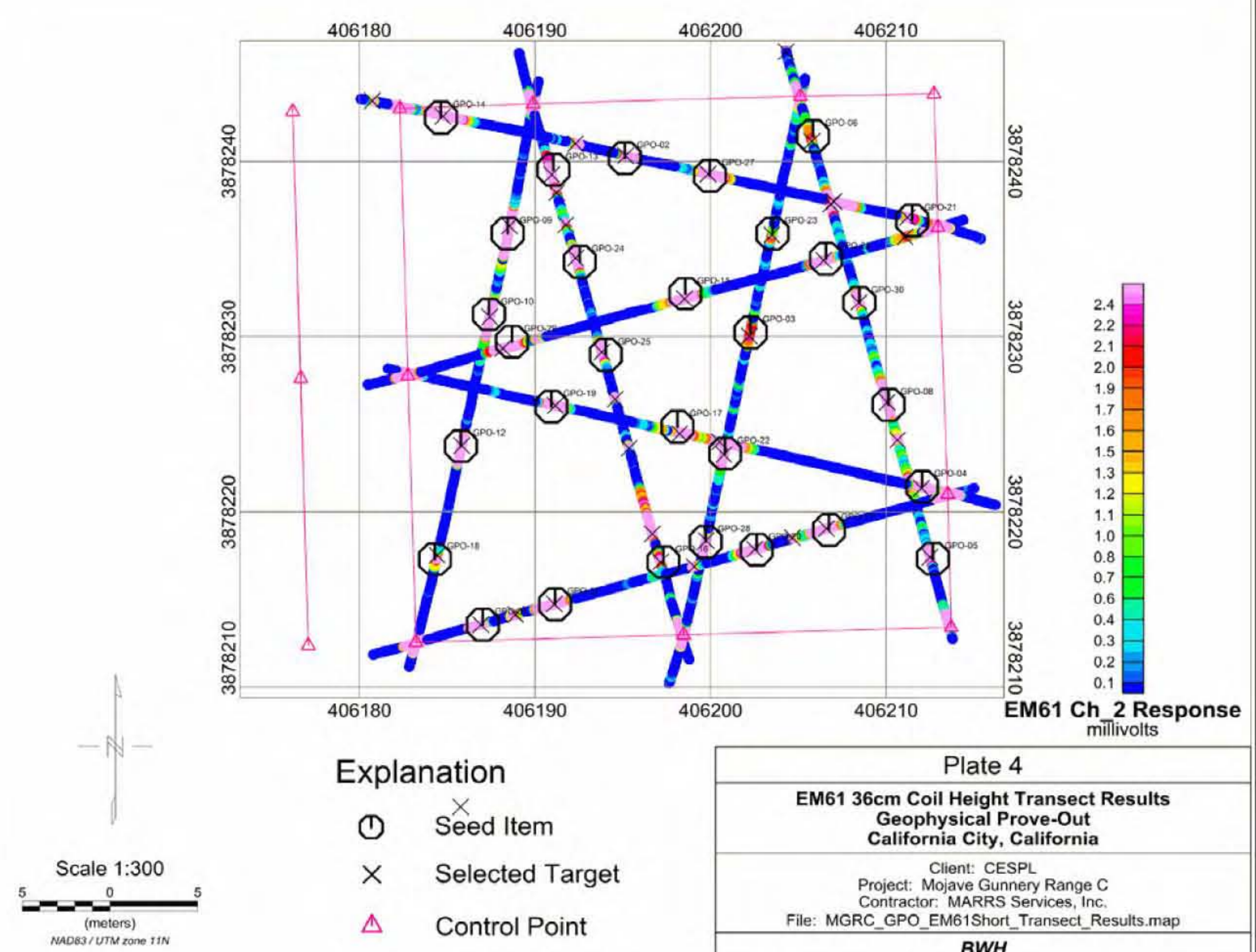
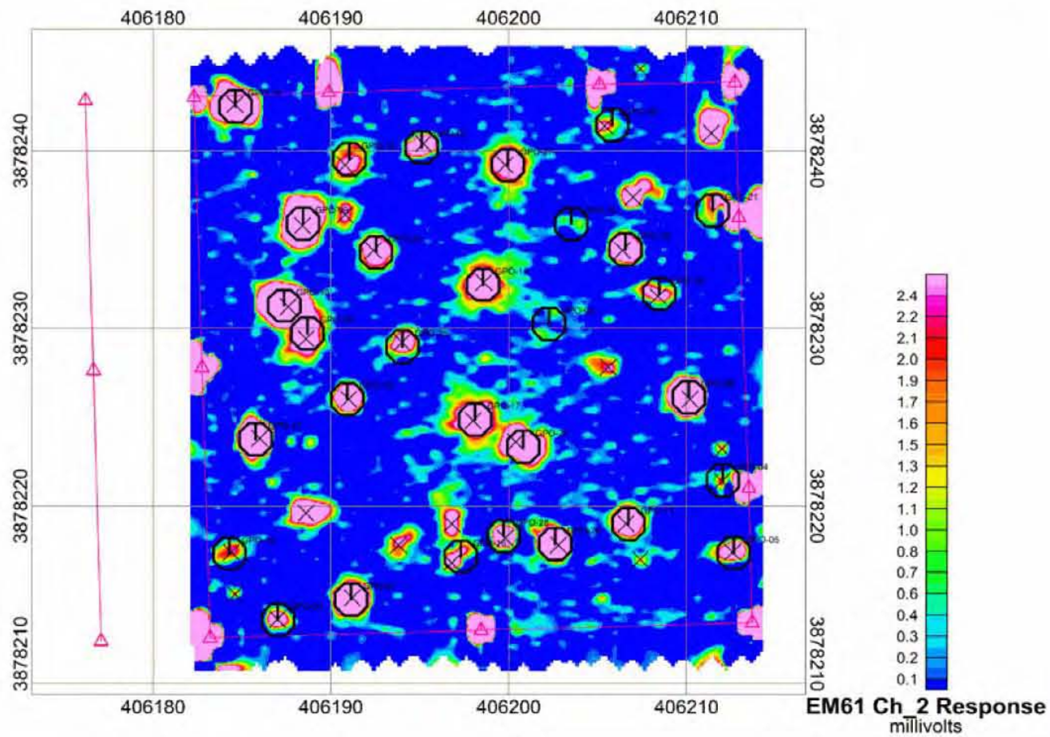


Plate 4

EM61 36cm Coil Height Transect Results
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_EM61Short_Transect_Results.map

BWH



Explanation

- Seed Item
- Selected Target
- Control Point

Scale 1:300

5 0 5

(meters)

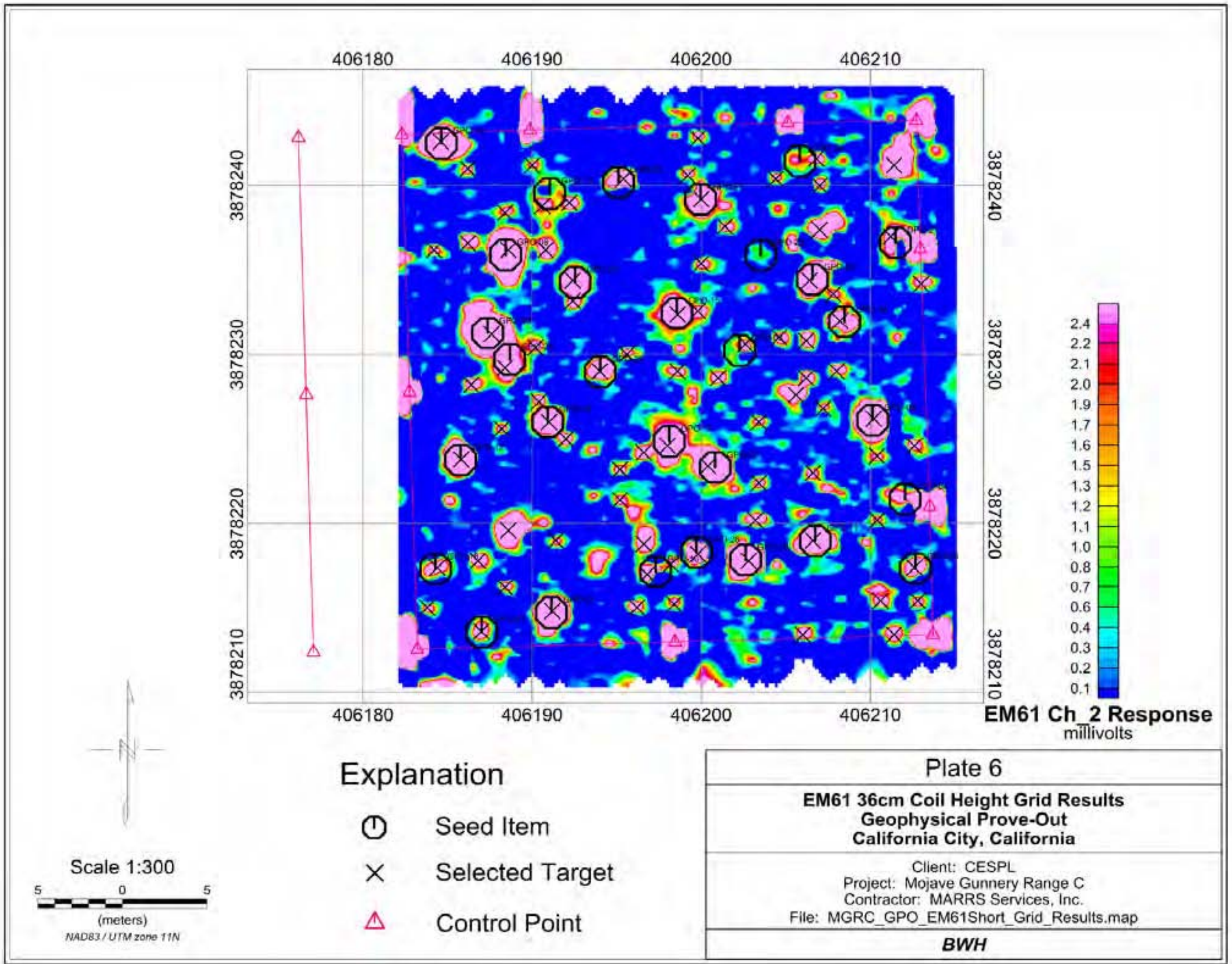
NAD83 / UTM zone 11N

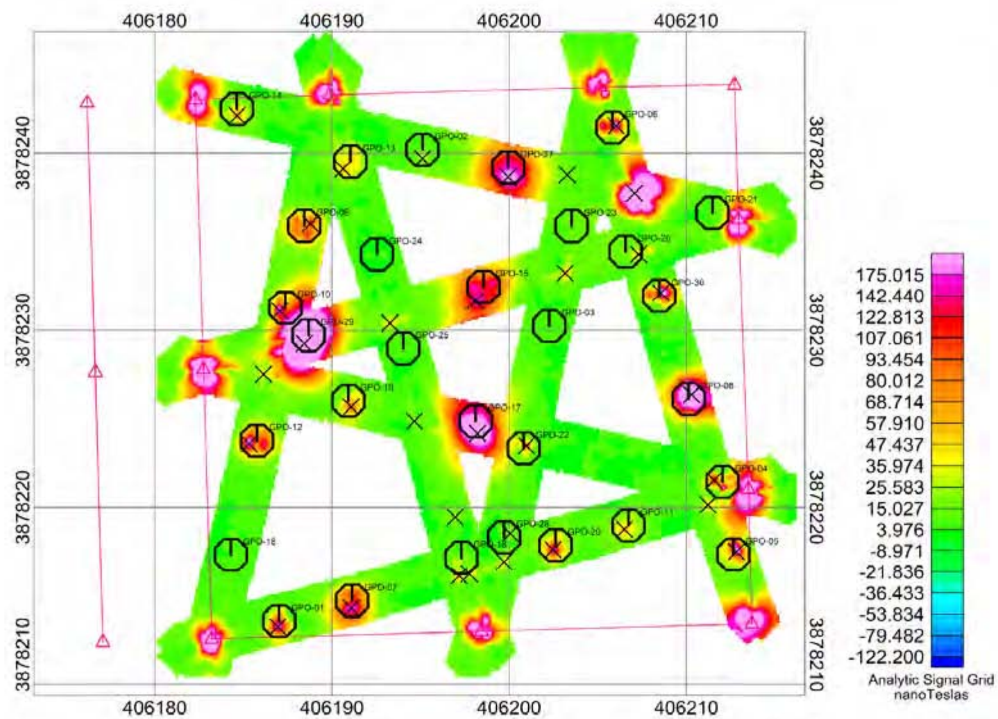
Plate 5

EM61 40cm Coil Height Grid Results
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_EM61Standard_Grid_Results.map

BWH


406180
406190
406200
406210
3878240
3878230
3878220
3878210
2.4
2.2
2.1
2.0
1.9
1.7
1.6
1.5
1.3
1.2
1.1
1.0
0.8
0.7
0.6
0.4
0.3
0.2
0.1
EM61 Ch_2 Response
millivolts
Explanation
Seed Item
Selected Target
Control Point
Scale 1:300
5
0
5
(meters)
NAD83 / UTM zone 11N
Plate 6
EM61 36cm Coil Height Grid Results
Geophysical Prove-Out
California City, California
Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_EM61Short_Grid_Results.map
BWH



Scale 1:300

5 0 5

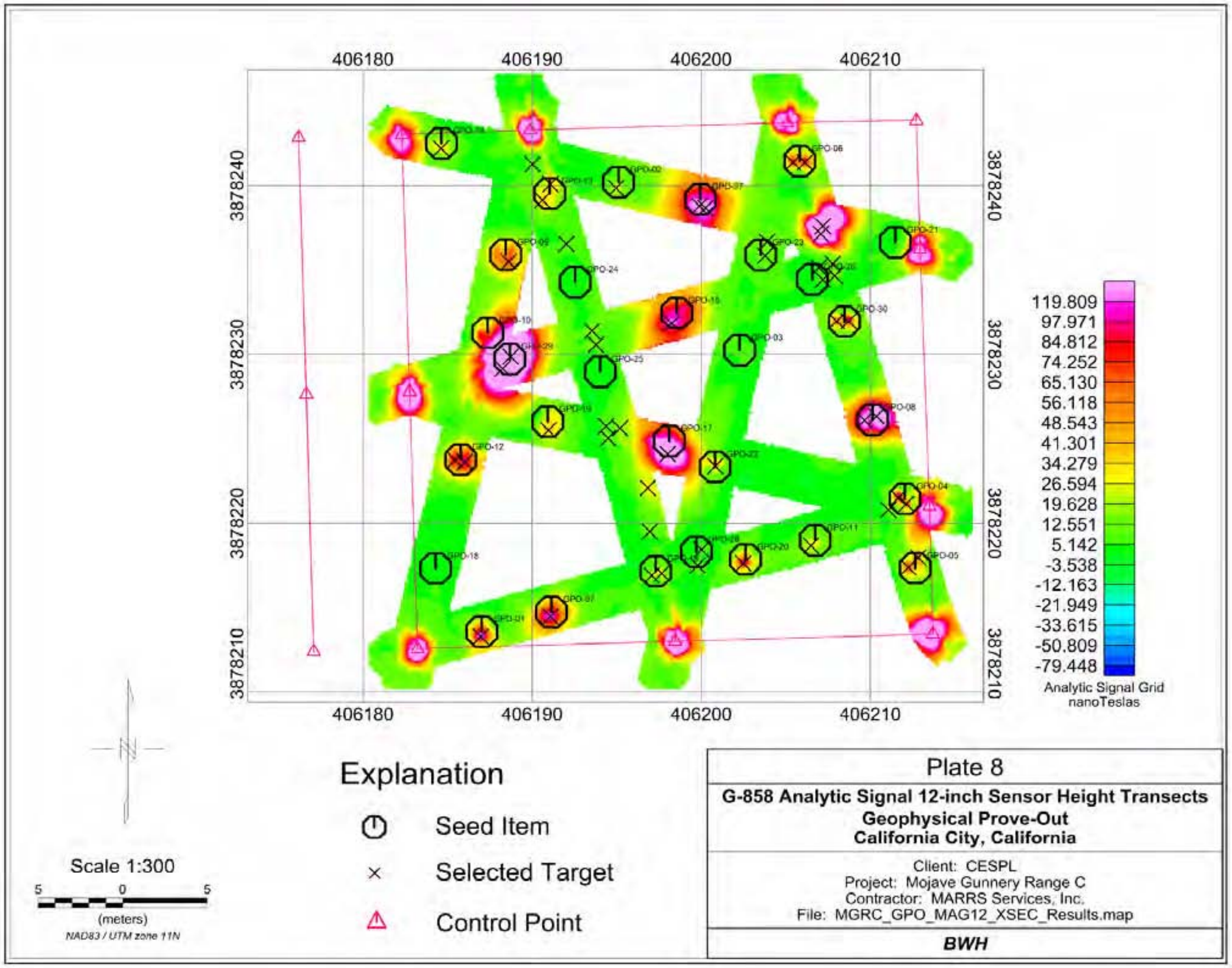
(meters)

NAD83 / UTM zone 11N

Explanation

- Seed Item
- × Selected Target
- Control Point

Plate 7
G-858 Analytic Signal 6-inch Sensor Height Transects **Geophysical Prove-Out** **California City, California**
Client: CESPL Project: Mojave Gunnery Range C Contractor: MARRS Services, Inc. File: MGRC_GPO_MAG6_XSEC_Results.map
BWH


406180
406190
406200
406210
3878240
3878230
3878220
3878210
119.809
97.971
84.812
74.252
65.130
56.118
48.543
41.301
34.279
26.594
19.628
12.551
5.142
-3.538
-12.163
-21.949
-33.615
-50.809
-79.448
Analytic Signal Grid
nanoTeslas
Explanation
Seed Item
Selected Target
Control Point
Scale 1:300
5 0 5
(meters)
NAD83 / UTM zone 11N
Plate 8
G-858 Analytic Signal 12-inch Sensor Height Transects
Geophysical Prove-Out
California City, California
Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_MAG12_XSEC_Results.map
BWH

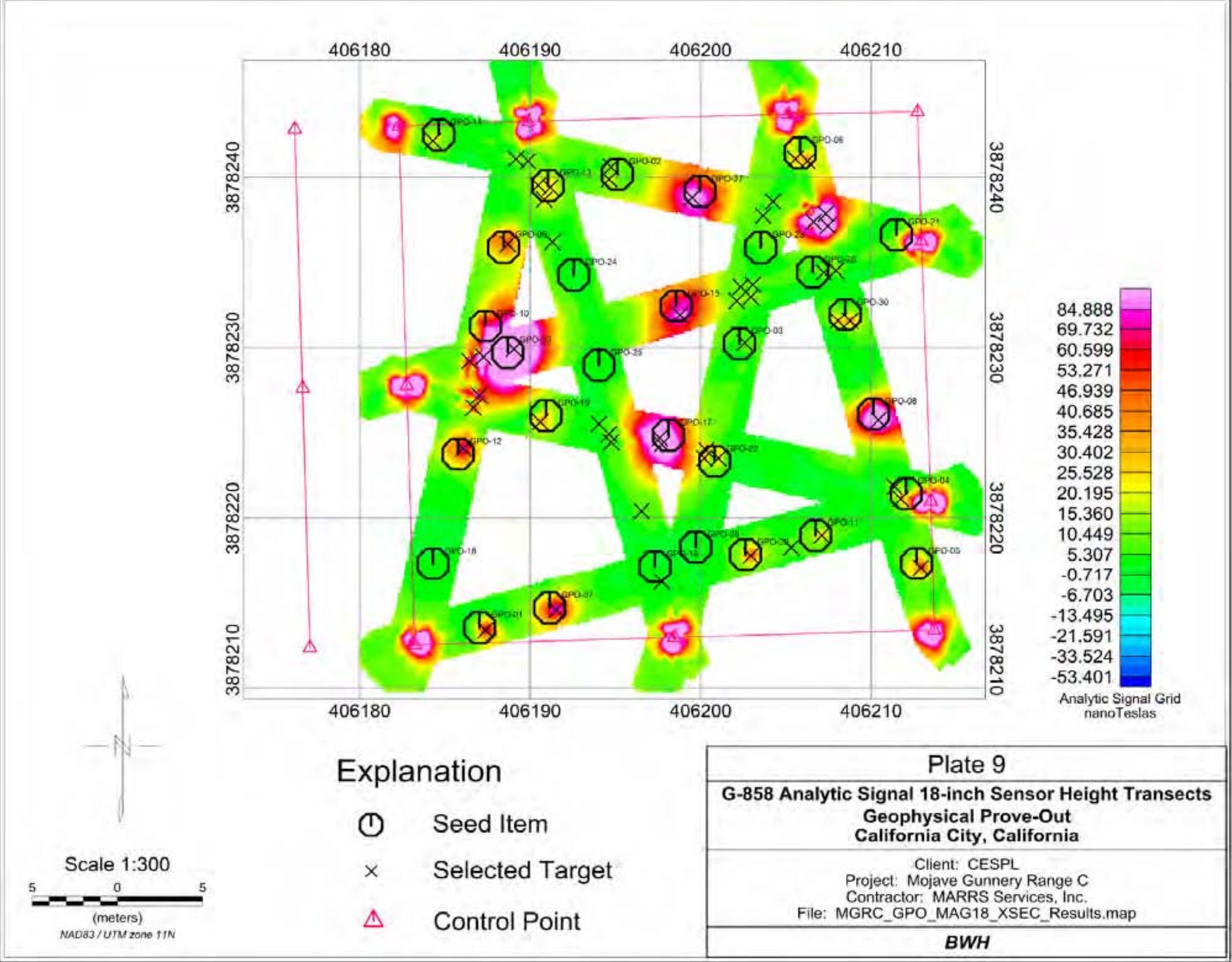
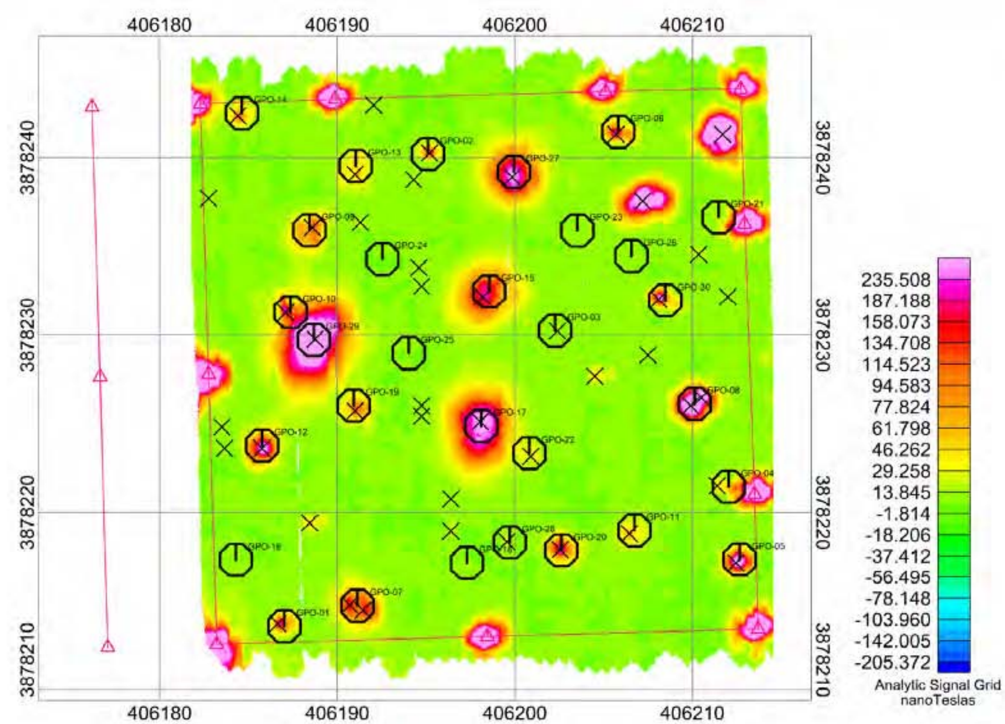


Plate 9

G-858 Analytic Signal 18-inch Sensor Height Transects
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_MAG18_XSEC_Results.map

BWH



Explanation

- Seed Item
- Selected Target
- Control Point

Scale 1:300

5 0 5

(meters)

NAD83 / UTM zone 11N

Plate 10

G-858 Analytic Signal 6-inch Sensor Height Grid
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_MAG6_Grid_Results.map

BWH

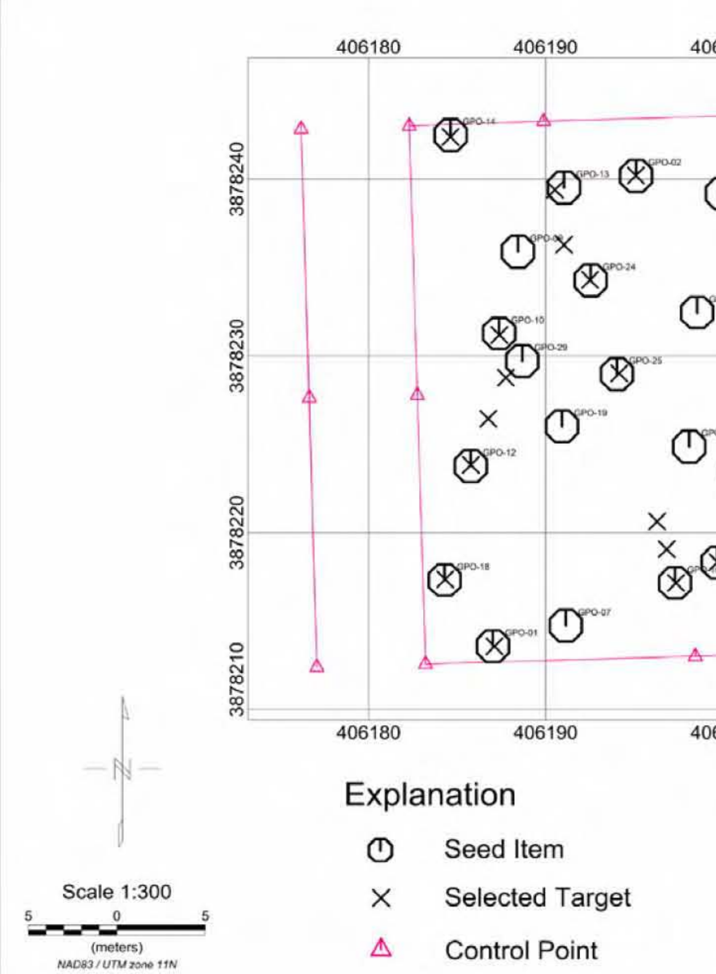


Plate 11

Garrett GTI 2500 Handheld Transect Results
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_Garrett_Transect_Results.map

BWH

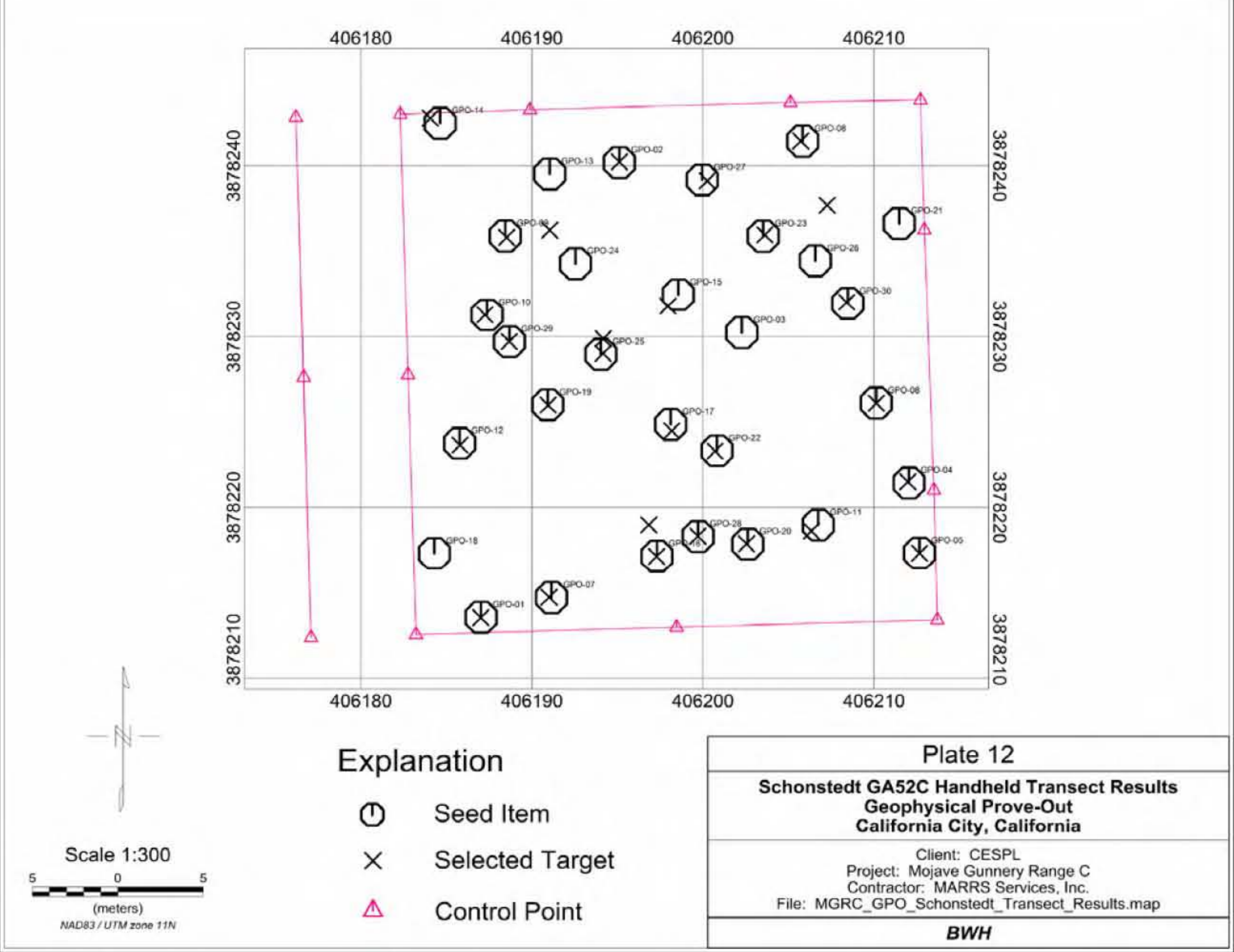


Plate 12

Schonstedt GA52C Handheld Transect Results
Geophysical Prove-Out
California City, California

Client: CESPL
Project: Mojave Gunnery Range C
Contractor: MARRS Services, Inc.
File: MGRC_GPO_Schonstedt_Transect_Results.map

BWH